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BBOB 2010: Comparison Tables of All Algorithms on All Noiseless Functions

Anne Auger — Steffen Finck — Nikolaus Hansen — Raymond Ros

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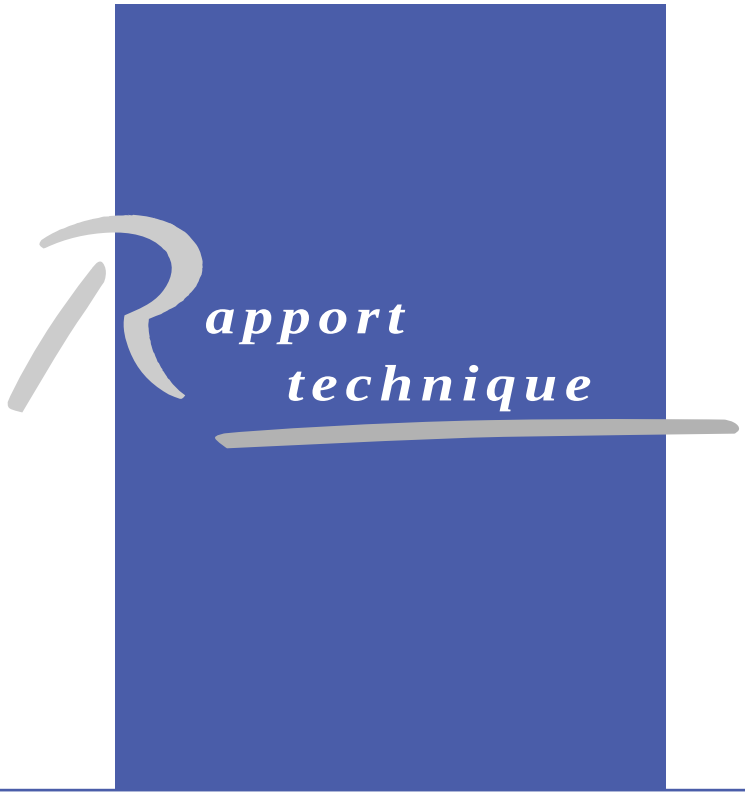
Domaine 1



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BBOB 2010: Comparison Tables of All Algorithms on All Noiseless Functions

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Domaine : Mathématiques appliquées, calcul et simulation
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Abstract: This document presents the results from the BBOB Black-Box Optimization Benchmarking workshop of the GECCO Genetic and Evolutionary Computation Conference 2010 in tables. Each table presents the performance of each algorithm submitted to BBOB 2010 on one function and dimension from the noiseless testbed.

Key-words: continuous optimization, benchmarking

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BBOB 2010: Tables de comparaison de tous les algorithmes sur toutes les fonctions non-bruitées

Résumé : Ce document présente les résultats sous forme de table du workshop Black-Box Optimization Benchmarking (BBOB) de la conférence Genetic and Evolutionary Computation Conference (GECCO), Portland, Oregon, Etats-Unis, 2010. Chaque table présente les performances des algorithmes soumis à BBOB 2010 pour un problème de la suite de fonctions tests.

Mots-clés : optimisation continue, banc d'essai

This document provides tabular results of the workshop for Black-Box Optimization Benchmarking (BBOB) at GECCO 2010[1]. Many algorithms have been tested on 24 benchmark functions in dimensions between 2 and 40. A description of the used objective functions can be found in [15, 11]. The experimental set-up is described in [14].

The performance measure provided in the following tables is the expected number of objective function evaluations to reach a given target function value (ERT, expected running time), divided by the respective value for the best algorithm. Consequently, the best (smallest) value is 1 and the value 1 appears in each column at least once. If the target was never reached, the median over all trials of the best function value is shown. See [14] for details on how ERT is obtained. Bold entries in the table correspond to values below 3 or the top-three best values.

List of Tables

[1] see http://coco.gforge.inria.fr/doku.php?id=bbob-2010

Table 1: Running time excess ERT/$\text{ERT}_{\text{best 2009}}$ on f_1 in **2-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

1 Sphere

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
ERT_{best}/D	0.50	0.50	0.90	2.8	2.8	3.1	3.1	3.1	3.1	3.1	ERT_{best}/D
(1,2)-CMA-ES	**1**	**1**	4.9	7.8	14	19	24	32	38	53	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	**1**	**1**	**2.1**	**2.3**	8.4	15	19	28	34	48	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	**1**	**1**	**2.8**	**2.9**	6.5	11	17	24	29	39	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	**1**	**1**	5.2	3.4	8.2	11	20	28	36	49	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	**1**	**1**	3.8	3.4	6.4	9.4	14	20	24	32	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	**1**	**1**	**2.1**	**2.3**	6.6	10	16	19	22	30	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	**1**	**1.1**	3.3	**2.4**	**4.8**	**8.5**	**11**	**14**	**17**	**24**	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	**1**	**1**	5.1	3.5	6.4	**9.0**	13	16	**19**	**25**	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	**1**	**1**	**2.9**	3.4	7.1	11	13	18	20	27	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	**1**	**1**	3.0	**2.4**	**6.0**	9.3	**13**	**16**	20	25	(1+2ms)-CMA-ES [2]
Artif Bee Colony	**1**	**1**	**2.3**	7.4	22	38	60	82	105	151	Artif Bee Colony [8]
avg NEWUOA	**1**	**1**	**1.9**	**1.1**	**1.1**	**0.97**	**0.97**	**0.97**	**0.97**	**0.97**	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	**1**	7.7	14	7.3	15	22	47	66	94	125	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	**1**	**1**	3.6	6.1	19	29	39	58	69	101	Adap DE (F-AUC) [10]
DE (Uniform)	**1**	**1**	**2.5**	4.5	18	31	44	57	71	100	DE (Uniform) [9]
IPOP-aCMA-ES	**1**	**1**	3.6	3.3	8.3	11	17	22	26	36	IPOP-aCMA-ES [16]
IPOP-CMA-ES	**1**	**1**	5.1	4.5	10	15	19	23	27	36	IPOP-CMA-ES [22]
CMA+DE-MOS	**1**	**1**	**2.3**	3.6	22	44	74	92	122	171	CMA+DE-MOS [18]
NBC-CMA	**1**	**1**	**2.5**	4.1	29	53	69	85	94	116	NBC-CMA [21]
POEMS	**1**	**1**	172	84	116	324	694	986	1394	1965	POEMS [17]
PM-AdapSS-DE	**1**	**1.1**	**2.3**	3.3	16	25	38	55	67	91	PM-AdapSS-DE [9, 10]
pPOEMS	**1**	**1**	54	82	153	342	2401	4014	6242	12106	pPOEMS [17, 20]
Basic RCGA	**1**	**1**	**2.2**	9.2	46	77	188	346	466	734	Basic RCGA [24]
SPSA	**1**	27	42	20	26	28	33	38	46	61	SPSA [13]

Table 2: Running time excess ERT/$\text{ERT}_{\text{best 2009}}$ on f_2 in **2-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

2 Ellipsoid separable

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
ERT_{best}/D	4.9	6.2	8.2	9.5	12	13	13	14	14	14	ERT_{best}/D
(1,2)-CMA-ES	10	42	67	80	65	66	66	65	64	67	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	15	30	85	99	85	86	86	83	82	85	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	4.8	26	55	70	61	62	63	61	61	63	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	4.9	46	201	214	168	166	166	160	157	156	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	**3.0**	**4.8**	17	26	24	26	27	26	27	28	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	4.3	6.2	23	29	25	25	26	26	26	28	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	**3.5**	6.0	18	19	18	19	19	19	19	20	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	3.6	9.3	19	26	22	23	23	23	23	24	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	4.2	8.1	**11**	16	**14**	**15**	**15**	**15**	**16**	**17**	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	3.5	**4.8**	**5.8**	**11**	**11**	**12**	**12**	**13**	**13**	**14**	(1+2ms)-CMA-ES [2]
Artif Bee Colony	14	20	22	32	38	46	52	56	62	77	Artif Bee Colony [8]
avg NEWUOA	**1.2**	**1.1**	**1.9**	**5.6**	**8.5**	**10**	**14**	17	20	27	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	11	269	1331	1953	4172	4065	3995	3783	3689	3624	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	8.2	10	14	16	16	19	22	23	26	31	Adap DE (F-AUC) [10]
DE (Uniform)	8.0	10	12	16	16	19	22	23	27	32	DE (Uniform) [9]
IPOP-aCMA-ES	4.6	5.1	14	18	15	16	17	**17**	**18**	**19**	IPOP-aCMA-ES [16]
IPOP-CMA-ES	4.2	7.5	16	21	18	19	20	20	21	22	IPOP-CMA-ES [22]
CMA+DE-MOS	13	20	24	30	34	40	45	54	59	69	CMA+DE-MOS [18]
NBC-CMA	15	21	38	102	118	157	203	253	295	305	NBC-CMA [21]
POEMS	179	330	377	408	392	450	546	568	642	807	POEMS [17]
PM-AdapSS-DE	7.5	11	12	**15**	15	19	22	24	25	30	PM-AdapSS-DE [9, 10]
pPOEMS	156	708	1840	2152	2416	2672	3142	3515	4175	5218	pPOEMS [17, 20]
Basic RCGA	10	18	37	56	64	125	155	266	350	543	Basic RCGA [24]
SPSA	12	149	1599	8950	13921	17255	*33e-2/1e5*	.	.	.	SPSA [13]

Table 3: Running time excess ERT/$\text{ERT}_{\text{best 2009}}$ on f_3 in **2-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

3 Rastrigin separable

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
ERT_{best}/D	0.50	0.70	7.3	135	222	223	225	226	227	232	ERT_{best}/D
(1,2)-CMA-ES	**1.1**	3.2	14	15	47	47	47	47	47	46	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	**1**	**2.1**	**3.3**	8.4	28	35	43	43	43	42	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	**1.3**	3.0	**3.4**	6.2	18	25	25	25	25	25	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	**1**	4.7	18	15	44	44	43	51	51	50	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	**1.6**	**2.5**	10	8.8	14	14	14	14	14	14	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	**1**	**1.1**	3.5	3.8	5.4	6.1	6.1	6.1	6.2	6.2	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	**1.3**	**2.0**	**2.1**	3.0	8.5	11	11	11	11	11	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	**2.1**	4.5	5.3	7.1	20	24	24	24	24	24	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	**1**	**1.6**	5.6	12	26	26	26	26	26	26	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	**1**	**1.5**	9.2	6.6	8.6	8.6	8.6	8.6	8.6	8.5	(1+2ms)-CMA-ES [2]
Artif Bee Colony	**1.1**	**1.7**	5.6	**1.7**	**1.6**	**2.4**	**2.9**	3.5	4.1	5.0	Artif Bee Colony [8]
avg NEWUOA	**1**	**2.7**	5.1	**1.6**	3.2	3.2	3.2	**3.2**	**3.2**	**3.1**	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	5.1	10	96	273	443	726	1244	2884	2875	2815	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	**1.3**	**1.6**	5.3	**2.0**	**1.6**	**2.0**	**2.4**	**2.6**	**2.8**	**3.1**	Adap DE (F-AUC) [10]
DE (Uniform)	**1.2**	**1.6**	5.2	**2.0**	**1.7**	**2.3**	**2.5**	**2.7**	**2.9**	**3.1**	DE (Uniform) [9]
IPOP-aCMA-ES	**1.1**	**2.5**	4.2	3.5	7.1	7.4	7.6	7.7	7.8	8.0	IPOP-aCMA-ES [16]
IPOP-CMA-ES	**1.2**	4.2	4.2	3.3	7.7	8.0	8.7	8.9	9.0	9.1	IPOP-CMA-ES [22]
CMA+DE-MOS	**1.1**	**2.2**	6.7	**2.4**	**2.2**	**2.9**	3.4	3.8	4.3	5.1	CMA+DE-MOS [18]
NBC-CMA	**1.3**	**1.7**	6.3	4.9	6.5	9.4	10	10	10	10	NBC-CMA [21]
POEMS	**1**	220	42	10	12	18	23	29	32	41	POEMS [17]
PM-AdapSS-DE	**1.3**	**1.6**	5.0	**1.8**	34	34	34	34	34	34	PM-AdapSS-DE [9, 10]
pPOEMS	**1**	**2.1**	45	22	42	103	125	157	201	267	pPOEMS [17, 20]
Basic RCGA	**1.1**	**1.6**	5.9	18	18	38	67	79	81	83	Basic RCGA [24]
SPSA	22	10266	998	943	1281	*14e-1/1e5*	.	.	.	.	SPSA [13]

Table 4: Running time excess ERT/$\text{ERT}_{\text{best 2009}}$ on f_4 in **2-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

4 Skew Rastrigin-Bueche separ

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
ERT_{best}/D	0.50	0.50	11	172	230	248	261	270	272	283	ERT_{best}/D
(1,2)-CMA-ES	**1**	5.0	8.4	13	58	73	70	68	67	65	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	**1.1**	3.1	7.9	10	26	30	29	28	28	27	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	**1**	3.2	**2.2**	13	48	46	43	42	42	40	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	**1**	8.9	6.9	30	72	68	65	63	63	61	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	**1**	3.0	**1.3**	7.9	27	25	24	23	23	22	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	**1**	**2.7**	**2.0**	8.5	24	27	26	25	25	24	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	**1**	5.5	6.0	5.0	14	17	16	16	16	15	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	**1**	3.3	3.4	3.9	18	17	16	16	16	15	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	**1**	**2.0**	3.6	13	48	44	42	41	41	39	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	**1**	**1.5**	**1.7**	4.8	**13**	**12**	**12**	**11**	**11**	**11**	(1+2ms)-CMA-ES [2]
Artif Bee Colony	**1.0**	**2.7**	3.7	**1.9**	**2.6**	**3.0**	**3.4**	**3.9**	**4.6**	**5.6**	Artif Bee Colony [8]
avg NEWUOA	**1**	4.5	6.2	4.0	14	13	12	12	12	11	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	11	23	19	178	1790	5680	5391	5242	5200	4998	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	**1**	**2.8**	4.0	**2.0**	111	103	98	95	95	91	Adap DE (F-AUC) [10]
DE (Uniform)	**1**	**2.5**	4.5	**1.9**	111	104	142	137	136	131	DE (Uniform) [9]
IPOP-aCMA-ES	**1**	4.1	3.1	5.7	39	62	80	84	85	85	IPOP-aCMA-ES [16]
IPOP-CMA-ES	**1.1**	7.5	4.7	12	61	97	114	169	171	171	IPOP-CMA-ES [22]
CMA+DE-MOS	**1.1**	3.3	4.3	3.1	**5.2**	**5.8**	**6.1**	**6.3**	**6.8**	**7.6**	CMA+DE-MOS [18]
NBC-CMA	**1**	**2.7**	6.6	5.8	14	16	16	20	26	25	NBC-CMA [21]
POEMS	**1**	302	34	14	29	31	35	37	40	47	POEMS [17]
PM-AdapSS-DE	**1**	3.8	3.7	147	292	271	257	249	248	238	PM-AdapSS-DE [9, 10]
pPOEMS	**1**	**2.6**	34	31	45	103	131	150	180	216	pPOEMS [17, 20]
Basic RCGA	**1.1**	3.6	9.0	39	222	472	2793	*36e-3/5e4*	.	.	Basic RCGA [24]
SPSA	25	18094	4669	3783	*47e-1/1e5*	.	.	.	.	.	SPSA [13]

Table 5: Running time excess $\mathrm{ERT}/\mathrm{ERT}_{\text{best 2009}}$ on f_5 in **2-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

5 Linear slope

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
$\mathrm{ERT}_{\text{best}}$/D	0.50	0.50	1.8	2.2	2.2	2.2	2.2	2.2	2.2	2.2	$\mathrm{ERT}_{\text{best}}$/D
(1,2)-CMA-ES	**1**	**1**	5.0	8.3	9.0	9.0	9.0	9.0	9.0	9.0	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	**1**	**1**	**2.6**	5.3	5.5	5.5	5.5	5.5	5.5	5.5	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	**1**	**1**	**1.7**	**2.8**	**2.9**	**3.0**	**3.0**	**3.0**	**3.0**	**3.0**	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	**1**	**1**	**2.1**	5.1	5.7	5.8	5.8	5.8	5.8	5.8	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	**1**	**1**	**3.0**	4.2	4.6	4.6	4.6	4.6	4.6	4.6	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	**1**	**1**	**2.5**	4.6	4.8	4.8	4.8	4.8	4.8	4.8	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	**1**	**1**	**2.1**	3.2	3.6	3.6	3.6	3.6	3.6	3.6	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	**1**	**1**	**2.3**	5.2	5.6	5.6	5.6	5.6	5.6	5.6	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	**1**	**1**	**2.2**	4.5	4.8	4.8	4.8	4.8	4.8	4.8	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	**1**	**1**	**1.8**	**2.9**	**3.2**	**3.2**	**3.2**	**3.2**	**3.2**	**3.2**	(1+2ms)-CMA-ES [2]
Artif Bee Colony	**1**	**1**	4.6	19	25	26	26	26	26	26	Artif Bee Colony [8]
avg NEWUOA	**1**	**1.2**	**1.1**	**1.5**	**1.6**	**1.6**	**1.6**	**1.6**	**1.6**	**1.6**	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	**1**	**1.1**	3.3	7.0	7.1	7.1	7.1	7.1	7.1	7.1	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	**1**	**1**	3.3	9.0	10	10	10	10	10	10	Adap DE (F-AUC) [10]
DE (Uniform)	**1**	**1.1**	5.1	14	15	15	15	15	15	15	DE (Uniform) [9]
IPOP-aCMA-ES	**1**	**1**	3.2	5.7	6.1	6.1	6.1	6.1	6.1	6.1	IPOP-aCMA-ES [16]
IPOP-CMA-ES	**1**	**1**	3.0	7.0	8.0	8.0	8.0	8.0	8.0	8.0	IPOP-CMA-ES [22]
CMA+DE-MOS	**1**	**1.2**	5.9	19	23	24	24	24	24	24	CMA+DE-MOS [18]
NBC-CMA	**1**	**1.1**	4.3	61	72	75	75	75	75	75	NBC-CMA [21]
POEMS	**1**	**1**	127	141	157	167	172	173	173	173	POEMS [17]
PM-AdapSS-DE	**1**	**1**	7.0	9.2	11	11	11	11	11	11	PM-AdapSS-DE [9, 10]
pPOEMS	**1**	**1**	63	147	160	164	165	165	165	165	pPOEMS [17, 20]
Basic RCGA	**1**	**1**	5.7	606	1162	2198	3308	4594	5752	33282	Basic RCGA [24]
SPSA	**1**	6.9	18	37	40	40	40	40	40	40	SPSA [13]

Table 6: Running time excess ERT/$\text{ERT}_{\text{best 2009}}$ on f_6 in **2-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

6 Attractive sector

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
ERT_{best}/D	0.83	1.4	6.3	11	20	27	34	40	47	62	ERT_{best}/D
(1,2)-CMA-ES	3.4	**2.4**	4.4	4.7	3.9	5.1	6.5	6.6	6.8	6.5	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	**2.7**	**2.5**	**2.4**	4.6	5.9	5.8	6.0	7.4	6.9	6.4	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	3.0	4.2	3.2	4.5	3.8	4.3	5.6	5.6	5.2	5.3	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	3.4	**2.8**	4.1	7.4	16	14	14	13	12	11	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	3.3	**2.8**	**1.6**	**2.8**	**2.6**	**2.9**	3.1	3.1	3.1	3.2	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	3.5	**2.3**	**1.4**	**2.2**	**2.7**	**3.0**	3.0	3.0	**3.0**	3.0	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	**1.8**	**1.5**	**1.7**	**2.7**	**2.5**	**2.4**	**2.5**	**2.4**	**2.4**	**2.3**	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	6.1	4.4	**2.0**	**2.6**	**2.7**	**2.6**	**2.7**	**2.8**	**2.7**	**2.6**	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	3.9	**2.7**	**2.1**	**2.5**	**2.2**	**2.3**	**2.2**	**2.2**	**2.1**	**2.1**	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	**2.1**	**1.6**	**1.1**	**1.9**	**1.8**	**2.0**	**1.9**	**2.0**	**2.0**	**2.0**	(1+2ms)-CMA-ES [2]
Artif Bee Colony	5.4	3.9	**2.8**	9.5	20	51	149	571	874	1167	Artif Bee Colony [8]
avg NEWUOA	**1.4**	**2.1**	3.1	4.7	3.9	4.4	4.4	4.5	4.7	4.6	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	13	132	72	909	1848	1428	1564	1318	1120	1129	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	**2.8**	**1.9**	**2.9**	5.9	6.3	7.3	7.8	8.5	8.6	8.9	Adap DE (F-AUC) [10]
DE (Uniform)	**2.8**	**3.0**	**2.9**	7.8	7.8	8.5	9.1	9.2	9.4	10	DE (Uniform) [9]
IPOP-aCMA-ES	4.2	**3.0**	**2.1**	3.2	3.2	3.5	4.0	4.0	4.0	3.8	IPOP-aCMA-ES [16]
IPOP-CMA-ES	4.6	3.5	**2.3**	5.0	4.2	4.7	4.5	4.6	4.4	4.5	IPOP-CMA-ES [22]
CMA+DE-MOS	3.2	**2.3**	**2.4**	12	13	16	16	18	17	18	CMA+DE-MOS [18]
NBC-CMA	3.1	**2.6**	**3.0**	8.4	33	28	24	22	20	17	NBC-CMA [21]
POEMS	204	157	61	92	99	112	121	138	136	147	POEMS [17]
PM-AdapSS-DE	**2.9**	**2.3**	**1.9**	4.0	6.1	8.2	8.8	9.0	8.8	8.9	PM-AdapSS-DE [9, 10]
pPOEMS	68	62	54	116	362	602	806	846	915	976	pPOEMS [17, 20]
Basic RCGA	4.3	16	6.0	121	375	596	1340	1819	3139	5724	Basic RCGA [24]
SPSA	75	4649	10152	8487	7901	8286	19888	*27e-2/1e5*	.	.	SPSA [13]

Table 7: Running time excess ERT/$\text{ERT}_{\text{best 2009}}$ on f_7 in **2-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

7 Step-ellipsoid

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
ERT_{best}/D	0.50	1	1.6	11	30	97	108	108	108	121	ERT_{best}/D
(1,2)-CMA-ES	**1.5**	3.5	6.2	6.5	24	13	37	37	37	259	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	**1.9**	**2.0**	5.5	9.2	10	17	23	23	23	54	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	**1.5**	**1.9**	4.3	4.5	13	24	32	32	32	69	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	**2.5**	3.5	21	21	15	27	35	35	35	89	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	**2.4**	**2.5**	5.1	3.6	4.1	**2.8**	**3.0**	**3.0**	**3.0**	4.3	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	**1.1**	**1.8**	4.9	5.7	4.8	4.9	5.3	5.3	5.3	5.6	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	**1.3**	**1.5**	16	6.3	4.4	**2.3**	**2.7**	**2.7**	**2.7**	6.4	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	**1.7**	**2.1**	**3.5**	5.0	3.8	3.6	5.6	5.6	5.6	7.7	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	**1.1**	**1.2**	**3.7**	**2.7**	**2.0**	**0.72**	**0.70**	**0.70**	**0.70**	**0.72**	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	**1.3**	**1.6**	4.7	4.3	**2.6**	**1.1**	**1.0**	**1.0**	**1.0**	**0.99**	(1+2ms)-CMA-ES [2]
Artif Bee Colony	**1.5**	**1.8**	6.4	4.2	9.5	17	60	60	60	123	Artif Bee Colony [8]
avg NEWUOA	**1.7**	**2.7**	4.0	3.7	6.8	5.0	10	10	10	9.0	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	268	296	861	719	589	936	1093	1093	1093	1610	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	**1.3**	**1.7**	**3.9**	**2.9**	**2.3**	**1.3**	**1.4**	**1.4**	**1.4**	**1.6**	Adap DE (F-AUC) [10]
DE (Uniform)	**1.8**	**2.5**	6.5	3.9	**2.8**	**1.3**	**1.3**	**1.3**	**1.3**	**1.4**	DE (Uniform) [9]
IPOP-aCMA-ES	**2.4**	**2.7**	6.2	3.8	**2.6**	**1.0**	**1.1**	**1.1**	**1.1**	**1.4**	IPOP-aCMA-ES [16]
IPOP-CMA-ES	**1.3**	**2.9**	7.4	4.0	3.7	**1.9**	**1.7**	**1.7**	**1.7**	**1.9**	IPOP-CMA-ES [22]
CMA+DE-MOS	**1.4**	**2.4**	4.3	3.9	5.2	3.0	3.4	3.4	3.4	3.5	CMA+DE-MOS [18]
NBC-CMA	**1.9**	**2.1**	4.0	3.9	4.5	**2.5**	**2.7**	**2.7**	**2.7**	4.5	NBC-CMA [21]
POEMS	182	189	166	39	41	19	22	22	22	24	POEMS [17]
PM-AdapSS-DE	**1.5**	**2.2**	4.3	**3.2**	**2.6**	**1.4**	**1.4**	**1.4**	**1.4**	**1.6**	PM-AdapSS-DE [9, 10]
pPOEMS	**1.7**	33	109	41	45	69	96	96	96	125	pPOEMS [17, 20]
Basic RCGA	**1.2**	**1.5**	4.1	7.0	81	127	240	240	240	302	Basic RCGA [24]
SPSA	354	7871	17652	39270	*34e-1/1e5*	.	.	.	.	.	SPSA [13]

Table 8: Running time excess ERT/$\text{ERT}_{\text{best 2009}}$ on f_8 in **2-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

8 Rosenbrock original

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
ERT_{best}/D	0.60	1.6	2.7	6.0	18	23	43	46	47	56	ERT_{best}/D
(1,2)-CMA-ES	6.5	6.0	26	65	36	35	22	22	23	20	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	5.2	4.1	24	47	27	30	18	18	18	16	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	5.3	5.4	5.7	19	15	21	12	12	12	11	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	6.1	4.5	53	236	123	117	87	90	96	82	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	4.8	3.1	5.3	22	14	13	8.0	8.2	8.4	7.7	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	3.4	3.8	5.5	8.0	6.8	7.9	5.4	5.7	6.1	5.6	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	3.3	**2.7**	**2.9**	10	7.0	8.7	5.1	5.0	5.2	4.7	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	3.1	**2.6**	5.6	18	11	11	7.0	7.2	7.2	6.5	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	4.1	3.1	5.2	12	6.5	**6.8**	**4.0**	**4.2**	**4.3**	**4.0**	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	**2.5**	**1.9**	**3.6**	**6.6**	**5.0**	**5.3**	**3.2**	**3.2**	**3.4**	**3.2**	(1+2ms)-CMA-ES [2]
Artif Bee Colony	3.7	**2.6**	5.7	10	18	188	822	4247	18261	*92e-6/1e5*	Artif Bee Colony [8]
avg NEWUOA	3.9	**2.5**	**2.6**	**4.6**	**2.4**	**2.4**	**1.4**	**1.4**	**1.4**	**1.3**	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	36	16	20	42	34	43	24	26	26	25	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	4.6	3.9	7.3	11	**6.3**	10	6.7	7.7	8.2	8.5	Adap DE (F-AUC) [10]
DE (Uniform)	**2.9**	**2.9**	6.6	10	399	320	173	163	161	136	DE (Uniform) [9]
IPOP-aCMA-ES	5.2	4.5	6.6	**7.9**	7.6	8.6	5.2	5.2	5.6	5.2	IPOP-aCMA-ES [16]
IPOP-CMA-ES	9.2	5.2	5.5	14	10	11	6.3	6.4	6.7	6.1	IPOP-CMA-ES [22]
CMA+DE-MOS	**2.6**	**2.9**	6.2	16	15	22	14	15	17	17	CMA+DE-MOS [18]
NBC-CMA	**2.9**	3.5	6.0	10	13	20	13	14	17	17	NBC-CMA [21]
POEMS	238	111	207	379	173	185	119	138	177	193	POEMS [17]
PM-AdapSS-DE	3.4	3.3	6.9	8.0	7.5	8.5	6.0	6.9	7.5	7.9	PM-AdapSS-DE [9, 10]
pPOEMS	40	85	111	109	128	486	463	546	796	1002	pPOEMS [17, 20]
Basic RCGA	**2.6**	3.1	10	16	144	478	781	1572	7166	12810	Basic RCGA [24]
SPSA	931	548	3157	7112	22724	61485	33559	*85e-2/1e5*	.	.	SPSA [13]

Table 9: Running time excess ERT/$\text{ERT}_{\text{best 2009}}$ on f_9 in **2-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

9 Rosenbrock rotated

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
ERT_{best}/D	0.50	0.50	0.50	8.9	15	22	34	38	41	46	ERT_{best}/D
(1,2)-CMA-ES	**2.9**	8.1	69	38	55	51	36	33	32	29	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	**2.7**	10	24	19	26	28	21	19	19	18	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	3.2	**6.1**	22	15	22	22	17	16	16	15	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	3.3	**6.4**	21	43	108	87	65	60	59	55	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	6.0	10	**21**	8.0	11	11	8.1	7.5	7.7	7.4	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	**2.7**	6.9	22	**3.2**	11	9.5	7.5	7.1	7.1	7.2	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	**2.9**	8.3	29	**4.0**	**6.1**	6.2	4.7	4.5	4.5	4.6	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	3.5	9.1	**15**	8.3	10	10	8.0	7.5	7.6	7.2	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	5.3	10	21	5.5	6.4	**5.7**	**4.2**	**4.1**	**4.2**	**4.1**	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	3.5	6.9	26	5.0	**5.3**	**5.1**	**3.7**	**3.6**	**3.6**	**3.7**	(1+2ms)-CMA-ES [2]
Artif Bee Colony	3.9	10	29	6.8	14	42	242	1552	5121	9398	Artif Bee Colony [8]
avg NEWUOA	7.7	10	22	**4.7**	**4.0**	**3.2**	**2.3**	**2.1**	**2.0**	**1.9**	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	16	39	693	65	58	49	34	31	31	29	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	5.0	14	44	7.9	489	342	224	200	388	344	Adap DE (F-AUC) [10]
DE (Uniform)	3.1	8.9	28	7.3	10	12	10	10	10	11	DE (Uniform) [9]
IPOP-aCMA-ES	**2.0**	**4.8**	22	6.8	8.8	8.0	6.3	5.8	6.0	5.9	IPOP-aCMA-ES [16]
IPOP-CMA-ES	3.7	11	39	10	12	11	7.8	7.4	7.3	7.2	IPOP-CMA-ES [22]
CMA+DE-MOS	**1.9**	11	**20**	6.2	8.4	11	11	11	13	14	CMA+DE-MOS [18]
NBC-CMA	3.3	7.3	32	8.1	18	17	13	14	16	17	NBC-CMA [21]
POEMS	337	444	558	58	75	104	106	106	127	156	POEMS [17]
PM-AdapSS-DE	7.1	19	33	11	497	716	467	412	390	346	PM-AdapSS-DE [9, 10]
pPOEMS	159	319	558	51	173	500	609	674	894	1105	pPOEMS [17, 20]
Basic RCGA	3.3	10	49	8.0	29	206	994	1278	2857	15260	Basic RCGA [24]
SPSA	469	1759	55199	8901	*96e-2/1e5*	.	.	.	.	.	SPSA [13]

Table 10: Running time excess ERT/ERT$_{\text{best 2009}}$ on f_{10} in **2-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

10 Ellipsoid

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
ERT$_{\text{best}}$/D	2.9	5.7	15	23	27	30	34	38	41	49	ERT$_{\text{best}}$/D
(1,2)-CMA-ES	13	56	39	39	36	34	30	28	27	23	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	8.9	25	49	36	33	30	27	26	25	22	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	6.4	14	29	23	22	23	21	20	19	17	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	6.7	109	120	115	106	95	92	85	80	68	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	6.4	6.0	8.9	11	11	11	10	9.2	8.8	8.0	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	7.9	10	12	13	12	11	10	10	9.4	8.5	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	6.1	**5.9**	7.9	7.5	8.1	7.6	7.1	6.8	6.6	5.9	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	**5.8**	8.7	8.8	8.3	8.7	8.4	8.4	7.9	7.5	6.7	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	9.3	7.0	6.4	**5.5**	**5.6**	**5.6**	**5.2**	**5.0**	**5.0**	**4.6**	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	**5.9**	**4.6**	**5.7**	5.6	**5.4**	**5.0**	**4.8**	**4.6**	**4.5**	**4.2**	(1+2ms)-CMA-ES [2]
Artif Bee Colony	12	13	20	97	771	6940	*11e-3/1e5*	.	.	.	Artif Bee Colony [8]
avg NEWUOA	**2.6**	**3.6**	**3.8**	**4.8**	6.9	7.6	8.8	9.5	10	11	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	13	62	144	364	642	865	772	697	647	545	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	12	10	6.8	6.9	7.2	7.8	8.2	8.4	8.5	8.6	Adap DE (F-AUC) [10]
DE (Uniform)	9.1	10	7.2	7.0	7.5	8.1	8.4	8.6	9.1	9.3	DE (Uniform) [9]
IPOP-aCMA-ES	8.8	8.8	**5.3**	**5.4**	**5.8**	**6.1**	**5.9**	**5.6**	**5.4**	**5.3**	IPOP-aCMA-ES [16]
IPOP-CMA-ES	9.4	9.1	10	8.7	8.4	7.8	7.5	7.1	6.9	6.4	IPOP-CMA-ES [22]
CMA+DE-MOS	13	14	13	19	20	20	20	20	20	20	CMA+DE-MOS [18]
NBC-CMA	16	24	25	51	64	77	81	90	96	87	NBC-CMA [21]
POEMS	103	87	302	742	1322	1758	1884	2353	2694	2655	POEMS [17]
PM-AdapSS-DE	8.8	10	7.4	6.5	7.3	7.4	7.8	8.2	8.5	8.9	PM-AdapSS-DE [9, 10]
pPOEMS	90	117	155	463	837	1017	1256	1447	1579	1747	pPOEMS [17, 20]
Basic RCGA	25	27	115	1504	1874	3104	6551	19727	*17e-3/5e4*	.	Basic RCGA [24]
SPSA	29	229	874	1873	16681	24345	*27e-2/1e5*	.	.	.	SPSA [13]

Table 11: Running time excess ERT/ERT$_{\text{best 2009}}$ on f_{11} in **2-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

11 Discus

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
ERT$_{\text{best}}$/D	4.7	5.7	18	22	25	31	34	38	41	49	ERT$_{\text{best}}$/D
(1,2)-CMA-ES	5.1	22	26	35	35	31	28	26	25	22	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	12	44	33	36	34	30	28	26	25	22	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	4.6	21	24	26	27	26	25	23	22	19	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	5.3	35	53	75	105	87	85	77	72	61	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	3.9	11	12	12	11	10	10	9.1	8.8	7.9	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	4.9	6.6	12	13	12	11	10	10	9.3	8.3	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	**3.2**	**6.1**	6.9	8.5	9.2	8.4	8.0	7.4	7.1	6.4	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	10	18	11	10	10	8.6	8.3	7.9	7.6	6.7	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	4.5	6.9	**4.2**	**6.5**	**6.7**	**5.8**	**5.5**	**5.3**	**5.1**	**4.8**	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	**3.9**	**5.6**	**3.3**	**5.5**	**5.6**	**5.0**	**4.9**	**4.6**	**4.6**	**4.2**	(1+2ms)-CMA-ES [2]
Artif Bee Colony	7.3	13	11	103	813	7859	40809	*11e-3/1e5*	.	.	Artif Bee Colony [8]
avg NEWUOA	**1.3**	**1.5**	**1.5**	**3.3**	**5.1**	**5.4**	6.8	7.3	8.0	8.8	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	8.1	128	517	994	1265	1264	1159	1041	962	812	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	7.6	13	6.3	7.0	8.0	7.9	8.2	8.7	8.8	9.0	Adap DE (F-AUC) [10]
DE (Uniform)	9.0	12	6.0	6.9	7.8	8.3	8.5	8.9	9.0	9.4	DE (Uniform) [9]
IPOP-aCMA-ES	4.2	6.7	5.1	6.7	6.9	6.2	**6.0**	**5.9**	**5.8**	**5.5**	IPOP-aCMA-ES [16]
IPOP-CMA-ES	5.1	12	7.5	8.3	8.7	7.6	7.4	7.1	6.8	6.4	IPOP-CMA-ES [22]
CMA+DE-MOS	11	23	13	19	23	21	21	21	21	20	CMA+DE-MOS [18]
NBC-CMA	13	22	24	41	58	66	87	97	101	88	NBC-CMA [21]
POEMS	68	69	533	811	1297	1891	2292	2546	2824	3255	POEMS [17]
PM-AdapSS-DE	7.9	12	6.2	7.3	8.2	8.3	8.8	9.1	9.1	9.4	PM-AdapSS-DE [9, 10]
pPOEMS	76	124	113	477	866	1087	1260	1491	1643	1787	pPOEMS [17, 20]
Basic RCGA	10	23	75	958	2135	6917	*44e-3/5e4*	.	.	.	Basic RCGA [24]
SPSA	15	483	1404	4983	17942	46844	42861	38450	*50e-2/1e5*	.	SPSA [13]

Table 12: Running time excess ERT/$\text{ERT}_{\text{best 2009}}$ on f_{12} in **2-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

12 Bent cigar

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
ERT_{best}/D	5.0	9.2	18	23	38	47	52	63	76	97	ERT_{best}/D
(1,2)-CMA-ES	5.9	12	12	24	27	31	33	31	35	30	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	5.4	30	32	28	26	26	24	22	20	21	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	21	38	42	52	43	37	34	29	25	21	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	5.9	37	95	170	142	116	105	88	73	57	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	9.3	12	16	21	18	16	16	14	13	11	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	8.6	11	16	21	19	18	17	16	15	13	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	4.5	8.0	16	22	18	16	15	14	12	10	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	**2.9**	6.8	14	20	16	15	14	13	11	10	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	4.6	7.0	8.8	10	7.7	**7.0**	**6.7**	**6.1**	**5.6**	**5.2**	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	4.6	**3.2**	**4.2**	**7.6**	**6.9**	**6.5**	**6.5**	**6.4**	**5.9**	**5.6**	(1+2ms)-CMA-ES [2]
Artif Bee Colony	8.9	7.7	13	175	568	1467	2630	3353	2793	2258	Artif Bee Colony [8]
avg NEWUOA	**1.7**	**1.1**	**0.96**	**1.6**	**1.5**	**1.5**	**1.5**	**1.5**	**1.4**	**1.4**	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	10	438	1070	8143	10929	8731	12445	22378	18388	*15e-1/1e5*	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	11	7.9	8.1	8.2	**7.5**	7.1	7.6	7.9	7.6	7.2	Adap DE (F-AUC) [10]
DE (Uniform)	10	7.7	8.1	320	417	334	302	253	209	165	DE (Uniform) [9]
IPOP-aCMA-ES	**4.4**	**3.8**	**5.0**	**7.8**	8.3	8.2	8.5	8.1	13	11	IPOP-aCMA-ES [16]
IPOP-CMA-ES	4.6	7.0	10	12	9.3	9.0	8.6	7.8	7.3	6.5	IPOP-CMA-ES [22]
CMA+DE-MOS	13	12	16	22	18	18	19	19	18	17	CMA+DE-MOS [18]
NBC-CMA	14	13	20	66	73	69	76	80	69	57	NBC-CMA [21]
POEMS	91	79	332	726	1039	1490	2235	2363	2530	2595	POEMS [17]
PM-AdapSS-DE	9.5	9.0	8.3	8.6	197	334	301	405	334	263	PM-AdapSS-DE [9, 10]
pPOEMS	76	78	282	408	622	667	730	788	801	843	pPOEMS [17, 20]
Basic RCGA	13	23	118	730	852	804	1022	912	1577	1575	Basic RCGA [24]
SPSA	3230	4072	15645	60799	37286	29781	*30e+0/1e5*	.	.	.	SPSA [13]

Table 13: Running time excess ERT/ERT$_{\text{best 2009}}$ on f_{13} in **2-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

13 Sharp ridge

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
ERT$_{\text{best}}$/D	0.50	2.3	11	18	23	30	35	42	47	61	ERT$_{\text{best}}$/D
(1,2)-CMA-ES	**2.2**	3.4	17	30	31	29	29	28	28	37	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	**1.1**	3.5	13	32	41	39	40	50	67	68	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	**2.1**	13	11	26	30	31	37	43	51	51	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	**1.1**	19	69	57	99	97	94	115	102	152	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	**1.3**	3.9	7.1	10	10	8.5	10	10	10	10	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	**1.7**	3.5	6.3	7.7	7.7	11	11	11	11	11	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	**1.5**	**2.4**	**2.9**	6.5	8.2	7.2	7.4	7.4	7.3	8.0	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	**1.3**	6.3	9.2	10	10	10	10	10	10	10	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	**1.4**	**2.3**	**4.1**	**5.6**	**6.8**	**6.6**	**6.1**	**6.0**	**7.1**	**8.0**	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	**1.1**	**1.8**	**3.7**	**5.6**	9.1	8.2	8.1	7.5	8.1	8.9	(1+2ms)-CMA-ES [2]
Artif Bee Colony	**1.4**	3.6	5.6	61	2262	18469	*23e-3/1e5*	.	.	.	Artif Bee Colony [8]
avg NEWUOA	**1.8**	6.7	6.7	17	38	54	73	131	140	771	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	17	95	386	2717	4951	9966	*48e-3/1e5*	.	.	.	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	**1.5**	4.1	4.5	6.9	8.2	8.5	9.3	9.4	9.3	9.5	Adap DE (F-AUC) [10]
DE (Uniform)	**1.5**	**2.8**	4.5	7.1	8.5	8.2	8.8	9.5	10	10	DE (Uniform) [9]
IPOP-aCMA-ES	**1.7**	4.2	4.3	**6.1**	**6.2**	**5.9**	**6.1**	**5.9**	**5.9**	**5.8**	IPOP-aCMA-ES [16]
IPOP-CMA-ES	**1.4**	**2.1**	5.0	6.3	**6.7**	**6.3**	**6.6**	**6.9**	**6.8**	**7.1**	IPOP-CMA-ES [22]
CMA+DE-MOS	**1.3**	**2.7**	7.7	17	19	19	20	20	19	19	CMA+DE-MOS [18]
NBC-CMA	**1.5**	3.0	7.9	14	17	25	44	52	48	40	NBC-CMA [21]
POEMS	125	104	54	103	146	491	1449	4402	15360	69407	POEMS [17]
PM-AdapSS-DE	**1.7**	3.3	5.2	6.4	7.8	8.1	8.7	9.1	9.2	9.1	PM-AdapSS-DE [9, 10]
pPOEMS	**1.4**	51	48	233	856	1073	1441	1587	1967	2202	pPOEMS [17, 20]
Basic RCGA	**1.4**	3.6	85	1010	2805	7126	20886	*19e-2/5e4*	.	.	Basic RCGA [24]
SPSA	23	27	47	332	2459	15906	20509	17764	31370	*21e-3/1e5*	SPSA [13]

Table 14: Running time excess ERT/$\text{ERT}_{\text{best 2009}}$ on f_{14} in **2-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

14 Sum of different powers

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
ERT_{best}/D	0.50	0.50	0.70	3.7	8.1	12	19	28	34	45	ERT_{best}/D
(1,2)-CMA-ES	**1**	**1.7**	9.2	10	7.4	11	18	20	22	29	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	**1**	**1.1**	**2.1**	**2.3**	4.5	5.5	11	14	22	30	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	**1**	**1**	**1.7**	**2.6**	3.9	4.7	10	13	19	24	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	**1**	**1.9**	**1.9**	3.9	8.3	13	29	56	64	86	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	**1**	**2.0**	**2.6**	**2.8**	**2.8**	4.3	4.8	5.8	7.3	8.7	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	**1**	**1.4**	**1.9**	**1.3**	**3.0**	3.8	6.1	6.3	7.9	10	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	**1**	**1.2**	**1.9**	**2.3**	**2.5**	**3.1**	4.1	4.4	5.3	7.0	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	**1**	**1.3**	**2.3**	**2.3**	**2.3**	3.3	5.1	5.6	7.2	8.2	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	**1**	**1**	**1.8**	**2.1**	**2.7**	**3.2**	**3.1**	**4.0**	**4.5**	**5.0**	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	**1**	**1.2**	**1.5**	**1.8**	3.1	3.5	**3.5**	**3.9**	**3.9**	**4.0**	(1+2ms)-CMA-ES [2]
Artif Bee Colony	**1**	**1.3**	**1.6**	4.7	10	18	27	607	11891	*22e-6/1e5*	Artif Bee Colony [8]
avg NEWUOA	**1**	**1.4**	3.4	**2.2**	**1.4**	**1.3**	**1.6**	**1.8**	**2.2**	6.8	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	4.3	7.9	19	17	10	15	21	25	37	581	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	**1**	**1.1**	**1.1**	3.6	5.6	10	10	8.4	8.7	9.0	Adap DE (F-AUC) [10]
DE (Uniform)	**1**	**1.5**	**1.7**	3.6	7.8	9.5	8.5	8.1	8.9	9.3	DE (Uniform) [9]
IPOP-aCMA-ES	**1**	**1.1**	**2.3**	**2.7**	3.3	4.9	4.9	4.9	4.8	**5.9**	IPOP-aCMA-ES [16]
IPOP-CMA-ES	**1**	**1.3**	**2.2**	**2.9**	4.6	5.1	4.7	5.2	6.0	7.2	IPOP-CMA-ES [22]
CMA+DE-MOS	**1**	**1.2**	**1.8**	4.3	13	17	18	18	19	20	CMA+DE-MOS [18]
NBC-CMA	**1**	**1.3**	**2.0**	**2.9**	11	17	14	13	16	22	NBC-CMA [21]
POEMS	**1**	185	213	74	67	141	165	177	246	2034	POEMS [17]
PM-AdapSS-DE	**1**	**1.5**	**1.7**	**2.7**	7.6	10	9.3	8.9	8.6	9.0	PM-AdapSS-DE [9, 10]
pPOEMS	**1**	**1.7**	**2.2**	57	66	391	760	984	1037	1666	pPOEMS [17, 20]
Basic RCGA	**1**	**1.2**	**1.5**	3.6	28	33	71	284	456	1630	Basic RCGA [24]
SPSA	22	57	242	984	530	452	850	5362	41592	31154	SPSA [13]

Table 15: Running time excess ERT/ERT$_{\text{best 2009}}$ on f_{15} in **2-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

15 Rastrigin

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
ERT$_{\text{best}}$/D	0.50	0.60	19	146	517	533	556	582	616	706	ERT$_{\text{best}}$/D
(1,2)-CMA-ES	**1.1**	4.2	**2.9**	14	17	17	16	15	15	13	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	**1.3**	**2.9**	**0.83**	7.8	10	13	13	13	12	11	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	**1**	4.2	**2.4**	6.8	9.5	9.2	8.9	8.5	8.1	7.1	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	**1**	5.6	9.5	15	20	24	23	22	21	18	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	**1.3**	5.4	**2.1**	3.6	**2.7**	**2.7**	**2.6**	**2.5**	**2.4**	**2.1**	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	**1.1**	4.4	**1.1**	**2.8**	4.7	4.9	4.7	4.5	4.3	3.8	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	**1.5**	3.4	**2.2**	3.6	5.0	4.9	4.7	4.5	4.2	3.7	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	**1.1**	4.7	**2.4**	5.8	9.4	9.1	8.8	8.4	7.9	7.0	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	**1**	**2.8**	3.1	4.0	6.5	6.3	6.1	5.8	5.5	4.9	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	**1.1**	**2.8**	**1.6**	3.4	6.0	5.8	5.6	5.4	5.1	4.5	(1+2ms)-CMA-ES [2]
Artif Bee Colony	**1.1**	**2.3**	**1.9**	8.8	17	75	164	309	495	672	Artif Bee Colony [8]
avg NEWUOA	**1**	**2.6**	**2.5**	**2.5**	3.3	3.2	3.1	**2.9**	**2.8**	**2.4**	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	4.9	189	108	64	158	331	418	1128	1067	933	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	**1.2**	**2.4**	**1.8**	**1.7**	**0.77**	**0.95**	**0.98**	**1.0**	**1.0**	**1.0**	Adap DE (F-AUC) [10]
DE (Uniform)	**1.2**	**2.1**	**1.8**	**1.5**	**0.67**	**0.88**	**0.95**	**0.97**	**1.0**	**1.0**	DE (Uniform) [9]
IPOP-aCMA-ES	**1.1**	3.9	**1.3**	**2.6**	**2.5**	**2.9**	**2.8**	**2.8**	**2.7**	**2.4**	IPOP-aCMA-ES [16]
IPOP-CMA-ES	**1**	**2.5**	**0.98**	**2.8**	**2.5**	**2.5**	**2.4**	**2.4**	**2.3**	**2.1**	IPOP-CMA-ES [22]
CMA+DE-MOS	**1**	**2.4**	**1.6**	4.0	**2.7**	3.3	3.4	3.4	3.3	3.1	CMA+DE-MOS [18]
NBC-CMA	**1.1**	**2.8**	**2.2**	**2.7**	3.2	4.2	4.2	4.2	4.0	3.6	NBC-CMA [21]
POEMS	**1**	143	17	20	76	76	75	74	71	65	POEMS [17]
PM-AdapSS-DE	**1.1**	**2.3**	**2.1**	**1.7**	15	14	14	13	13	11	PM-AdapSS-DE [9, 10]
pPOEMS	**1**	7.1	19	46	25	50	63	72	82	92	pPOEMS [17, 20]
Basic RCGA	**1**	**1.6**	3.1	32	32	40	51	62	79	114	Basic RCGA [24]
SPSA	28	962	39	1133	1352	*11e-1/1e5*	.	.	.	.	SPSA [13]

Table 16: Running time excess ERT/ERT$_{\text{best 2009}}$ on f_{16} in **2-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

16 Weierstrass

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
ERT$_{\text{best}}$/D	0.50	0.57	4.6	25	87	163	179	195	205	269	ERT$_{\text{best}}$/D
(1,2)-CMA-ES	**1**	**1.6**	3.0	14	19	44	74	120	115	125	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	**1**	**1.1**	23	14	32	21	20	21	21	19	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	**1**	**1.2**	12	20	27	21	29	34	48	41	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	**1**	**1.5**	23	39	41	74	107	725	696	530	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	**1**	**1.9**	10	13	7.1	4.2	**4.4**	4.9	4.8	4.0	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	**1**	**1.4**	4.0	9.1	5.4	4.3	4.4	**4.2**	7.6	5.8	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	**1**	**1.6**	**2.6**	5.9	**3.6**	5.3	4.9	4.6	5.3	4.2	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	**1**	**1.5**	7.6	10	10	6.2	12	12	11	21	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	**1**	**1.5**	5.6	6.8	5.6	5.6	7.4	10	12	10	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	**1**	**1.5**	3.6	7.6	5.4	7.6	7.7	11	11	10	(1+2ms)-CMA-ES [2]
Artif Bee Colony	**1**	**1.5**	**2.2**	**3.4**	8.7	38	202	1036	4754	3686	Artif Bee Colony [8]
avg NEWUOA	**1**	12	15	9.1	5.5	6.8	13	21	37	73	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	**1.7**	8.5	166	134	236	489	2332	*53e-4/1e5*	.	.	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	**1**	**1.6**	**1.5**	**4.9**	**3.5**	**3.6**	**4.0**	**4.1**	**4.1**	**3.5**	Adap DE (F-AUC) [10]
DE (Uniform)	**1**	**1.2**	**2.8**	6.8	4.0	3.8	4.6	4.6	4.7	4.0	DE (Uniform) [9]
IPOP-aCMA-ES	**1**	**1.1**	3.8	8.3	6.1	**3.7**	**3.6**	**3.4**	**3.3**	**2.7**	IPOP-aCMA-ES [16]
IPOP-CMA-ES	**1**	**1.4**	**2.5**	11	5.0	**3.5**	4.6	4.3	**4.2**	**3.4**	IPOP-CMA-ES [22]
CMA+DE-MOS	**1**	**1.6**	5.3	6.0	**3.8**	5.0	5.8	5.7	6.5	6.5	CMA+DE-MOS [18]
NBC-CMA	**1**	**1.5**	**2.4**	5.3	12	17	22	21	23	19	NBC-CMA [21]
POEMS	**1**	100	67	152	81	137	132	126	125	103	POEMS [17]
PM-AdapSS-DE	**1**	**1.2**	3.1	**4.2**	4.6	47	44	41	39	30	PM-AdapSS-DE [9, 10]
pPOEMS	**1**	**1.6**	39	22	58	106	162	229	264	283	pPOEMS [17, 20]
Basic RCGA	**1**	**1.5**	**1.8**	5.2	68	73	87	160	219	290	Basic RCGA [24]
SPSA	13	71	71	137	298	424	822	2207	7266	*30e-4/1e5*	SPSA [13]

Table 17: Running time excess ERT/$\mathrm{ERT}_{\text{best 2009}}$ on f_{17} in **2-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

17 Schaffer F7, condition 10

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
$\mathrm{ERT}_{\text{best}}$/D	0.50	0.50	1.3	30	66	138	198	372	543	828	$\mathrm{ERT}_{\text{best}}$/D
(1,2)-CMA-ES	**1**	**1.3**	38	9.1	18	17	59	393	*99e-5/1e4*	.	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	**1**	**1.3**	3.7	**1.6**	4.6	5.2	7.4	11	60	84	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	**1**	**1.1**	**1.8**	**2.5**	**2.9**	4.2	14	27	62	180	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	**1**	**2.9**	7.4	4.5	17	48	332	*33e-4/1e4*	.	.	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	**1**	**1.3**	3.8	**2.0**	3.6	3.1	5.0	5.7	13	39	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	**1**	**1.3**	3.2	**1.8**	**2.6**	**2.6**	**2.9**	3.7	12	18	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	**1.1**	**1.4**	**2.4**	5.2	3.3	**2.5**	3.7	11	36	32	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	**1**	**1.3**	6.2	**1.8**	3.7	5.3	10	27	*30e-6/1e4*	.	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	**1**	**2.5**	4.0	3.3	4.5	12	19	19	33	22	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	**1**	**1.9**	3.1	**1.7**	**2.2**	4.0	3.0	4.3	5.6	3.7	(1+2ms)-CMA-ES [2]
Artif Bee Colony	**1.0**	**1.3**	**2.2**	**2.5**	6.7	10	94	231	436	*29e-6/1e5*	Artif Bee Colony [8]
avg NEWUOA	**1.1**	**1.3**	12	4.6	13	33	117	*75e-4/5e3*	.	.	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	5.3	17	14	6.5	61	310	811	3768	*14e-4/1e5*	.	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	**1**	**1.1**	**2.9**	**1.9**	**2.5**	**2.0**	**2.1**	**1.5**	**1.3**	**1.2**	Adap DE (F-AUC) [10]
DE (Uniform)	**1**	**1.1**	**2.5**	**1.8**	**2.5**	**2.1**	**2.1**	**1.5**	**1.3**	**1.2**	DE (Uniform) [9]
IPOP-aCMA-ES	**1**	**1.3**	5.4	**2.6**	**2.2**	**1.8**	**1.5**	**1.2**	**1.3**	**1.1**	IPOP-aCMA-ES [16]
IPOP-CMA-ES	**1**	**1**	19	**2.4**	**2.0**	**1.6**	**1.7**	**1.4**	**1.5**	**1.1**	IPOP-CMA-ES [22]
CMA+DE-MOS	**1**	**1.5**	**2.2**	4.9	6.6	5.0	5.0	3.3	3.1	**2.6**	CMA+DE-MOS [18]
NBC-CMA	**1**	**1**	**1.9**	**2.8**	4.6	**3.0**	**2.5**	**1.7**	**1.5**	**2.1**	NBC-CMA [21]
POEMS	**1**	66	130	18	33	28	32	24	21	19	POEMS [17]
PM-AdapSS-DE	**1.1**	**1.2**	**2.5**	**1.6**	**2.2**	**2.0**	**2.1**	**1.5**	**1.4**	**1.2**	PM-AdapSS-DE [9, 10]
pPOEMS	**1**	**1.3**	51	23	116	179	220	157	142	133	pPOEMS [17, 20]
Basic RCGA	**1**	**1.2**	**2.9**	5.0	47	61	103	77	124	*23e-7/5e4*	Basic RCGA [24]
SPSA	1935	16834	27903	1683	771	1105	*17e-3/1e5*	.	.	.	SPSA [13]

Table 18: Running time excess $\mathrm{ERT}/\mathrm{ERT}_{\text{best 2009}}$ on f_{18} in **2-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

18 Schaffer F7, condition 1000

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
$\mathrm{ERT}_{\text{best}}$/D	0.50	1.6	10	67	333	625	854	1036	1219	1429	$\mathrm{ERT}_{\text{best}}$/D
(1,2)-CMA-ES	**1.1**	17	8.4	7.7	16	72	82	144	*28e-3/1e4*	.	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	**1.1**	25	6.5	17	17	53	168	138	*20e-3/1e4*	.	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	**1.5**	4.3	**1.7**	8.2	7.8	23	*13e-3/1e4*	.	.	.	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	**1.3**	3.1	74	41	39	*98e-3/1e4*	.	.	.	.	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	**1.1**	**2.4**	3.5	10	8.1	10	11	22	119	102	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	**1.1**	16	3.5	5.7	3.7	4.2	6.9	15	37	31	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	**1.1**	**1.4**	**0.70**	4.1	**2.6**	8.0	20	144	*14e-4/1e4*	.	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	**1.6**	**1.3**	**0.93**	6.7	6.3	12	15	144	*10e-4/1e4*	.	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	**1.7**	8.1	**2.4**	10	17	33	172	*16e-3/1e4*	.	.	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	**1**	**1.3**	**1.3**	7.6	12	39	173	143	*16e-3/1e4*	.	(1+2ms)-CMA-ES [2]
Artif Bee Colony	**1.2**	**1.1**	**2.4**	8.2	20	596	2565	*20e-3/1e5*	.	.	Artif Bee Colony [8]
avg NEWUOA	**1.7**	7.9	5.4	9.0	6.1	62	*58e-3/6e3*	.	.	.	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	8.2	8.1	12	463	541	*27e-2/1e5*	.	.	.	.	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	**1.1**	**1.3**	**2.6**	**1.4**	**0.73**	**0.62**	**0.66**	**0.68**	**0.74**	**0.81**	Adap DE (F-AUC) [10]
DE (Uniform)	**1.1**	**0.98**	**2.9**	**1.8**	**0.77**	**0.63**	**0.63**	**0.65**	**0.71**	**0.80**	DE (Uniform) [9]
IPOP-aCMA-ES	**2.1**	**2.1**	**1.4**	3.9	**1.2**	**0.78**	**0.71**	**0.71**	**0.85**	**0.92**	IPOP-aCMA-ES [16]
IPOP-CMA-ES	**1**	**2.9**	4.9	3.7	**1.5**	**1.1**	**1.1**	**1.1**	**1.0**	**1.1**	IPOP-CMA-ES [22]
CMA+DE-MOS	**1.5**	**1.3**	**2.5**	3.8	**2.6**	**1.9**	**2.1**	**1.9**	**2.6**	**2.5**	CMA+DE-MOS [18]
NBC-CMA	**1.1**	**1.1**	**2.4**	8.6	**2.9**	**2.3**	**2.3**	**2.1**	**2.0**	**2.2**	NBC-CMA [21]
POEMS	36	84	31	17	10	8.9	8.9	33	32	30	POEMS [17]
PM-AdapSS-DE	**1.1**	**0.90**	**2.6**	**1.5**	**0.71**	**0.65**	**0.63**	**0.65**	**0.70**	**0.77**	PM-AdapSS-DE [9, 10]
pPOEMS	**1.1**	11	29	37	56	57	63	70	77	94	pPOEMS [17, 20]
Basic RCGA	**1.1**	**1.4**	**2.1**	114	137	352	836	*71e-3/5e4*	.	.	Basic RCGA [24]
SPSA	24	6520	3903	2418	1211	2253	*10e-1/1e5*	.	.	.	SPSA [13]

Table 19: Running time excess ERT/$\text{ERT}_{\text{best 2009}}$ on f_{19} in **2-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

19 Griewank-Rosenbrock F8F2

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
ERT_{best}/D	0.50	0.50	0.50	0.50	13	108	114	120	126	138	ERT_{best}/D
(1,2)-CMA-ES	**1**	**1**	3.9	128	18	21	31	44	52	49	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	**1**	**1.1**	**2.7**	**30**	21	19	39	43	58	54	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	**1**	**1.2**	3.7	56	17	13	23	30	37	40	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	**1**	**1**	**3.1**	68	12	32	41	50	56	53	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	**1**	**1.1**	4.3	**28**	14	15	28	36	39	36	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	**1**	**1**	4.8	35	11	9.1	**10**	17	16	**15**	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	**1**	**1.2**	6.3	42	12	17	25	28	27	29	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	**1**	**1**	9.4	57	25	14	22	22	24	22	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	**1**	**1**	**3.1**	52	76	24	23	22	21	20	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	**1**	**1**	4.7	50	16	13	**12**	**12**	**11**	**10**	(1+2ms)-CMA-ES [2]
Artif Bee Colony	**1**	**1.1**	6.1	56	11	**7.7**	16	37	73	882	Artif Bee Colony [8]
avg NEWUOA	**1**	**1.3**	8.0	106	13	22	21	20	19	18	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	4.9	8.7	87	144	24	118	281	493	1300	2054	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	**1**	**1.3**	6.5	63	**8.3**	147	143	138	132	122	Adap DE (F-AUC) [10]
DE (Uniform)	**1**	**1.3**	3.9	36	8.8	72	70	67	67	62	DE (Uniform) [9]
IPOP-aCMA-ES	**1**	**1.4**	5.1	32	9.2	**8.7**	14	19	19	18	IPOP-aCMA-ES [16]
IPOP-CMA-ES	**1**	**1.1**	6.3	**22**	9.0	17	17	18	18	17	IPOP-CMA-ES [22]
CMA+DE-MOS	**1**	**1.1**	3.8	**30**	**6.7**	**1.9**	**3.1**	**4.0**	**5.0**	**5.4**	CMA+DE-MOS [18]
NBC-CMA	**1**	**1.3**	5.4	36	**7.9**	11	13	**16**	**16**	18	NBC-CMA [21]
POEMS	**1**	102	310	549	46	464	451	432	415	389	POEMS [17]
PM-AdapSS-DE	**1**	**2.1**	5.5	43	10	341	327	312	299	276	PM-AdapSS-DE [9, 10]
pPOEMS	**1**	**1.3**	68	539	49	38	81	122	185	258	pPOEMS [17, 20]
Basic RCGA	**1**	**1.1**	5.7	47	8.9	18	22	71	107	453	Basic RCGA [24]
SPSA	20	67	573	982	202	889	1595	2506	11291	*48e-4/1e5*	SPSA [13]

Table 20: Running time excess $\mathrm{ERT}/\mathrm{ERT}_{\text{best 2009}}$ on f_{20} in **2-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

20 Schwefel x*sin(x)

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
$\mathrm{ERT}_{\text{best}}/\mathrm{D}$	1.1	1.6	1.9	30	182	183	183	184	185	188	$\mathrm{ERT}_{\text{best}}/\mathrm{D}$
(1,2)-CMA-ES	6.4	4.8	6.0	15	24	37	37	37	37	37	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	**2.3**	**3.0**	3.2	13	24	34	34	34	34	33	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	**2.2**	**2.2**	**2.1**	17	31	54	54	54	54	53	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	5.7	45	98	20	38	51	52	57	57	56	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	3.2	3.4	3.1	9.3	6.9	7.8	7.8	7.9	7.9	7.9	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	**1.8**	**2.3**	**2.4**	10	12	13	13	13	13	13	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	3.2	3.6	3.7	11	14	15	17	17	17	17	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	**2.1**	**1.7**	**1.6**	8.4	10	11	12	12	12	12	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	**3.0**	3.1	3.6	16	4.9	4.9	**5.0**	**5.0**	**5.1**	**5.1**	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	**1.6**	**1.7**	**1.7**	11	4.8	**4.9**	**4.9**	**5.0**	**5.0**	**5.0**	(1+2ms)-CMA-ES [2]
Artif Bee Colony	**2.1**	**2.6**	**2.6**	4.6	**2.2**	**4.1**	6.0	7.8	10	16	Artif Bee Colony [8]
avg NEWUOA	**3.0**	**2.2**	**2.1**	10	**4.0**	**4.0**	**4.0**	**4.0**	**4.0**	**3.9**	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	22	17	15	60	336	1100	3695	*49e-3/1e5*	.	.	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	**2.0**	**2.9**	**2.9**	**4.6**	482	481	481	480	476	470	Adap DE (F-AUC) [10]
DE (Uniform)	**1.8**	**2.9**	**2.9**	**4.2**	276	276	276	276	274	270	DE (Uniform) [9]
IPOP-aCMA-ES	**1.8**	**1.4**	**1.8**	12	10	11	12	12	12	12	IPOP-aCMA-ES [16]
IPOP-CMA-ES	4.5	5.7	5.6	12	11	12	12	13	13	13	IPOP-CMA-ES [22]
CMA+DE-MOS	**2.0**	**2.6**	3.2	10	**4.8**	6.7	7.8	8.4	9.0	12	CMA+DE-MOS [18]
NBC-CMA	**2.2**	3.6	3.6	11	6.7	7.6	8.1	8.4	8.5	8.7	NBC-CMA [21]
POEMS	190	135	121	28	40	45	49	55	61	68	POEMS [17]
PM-AdapSS-DE	3.3	**2.5**	**2.2**	**4.0**	628	627	627	626	620	612	PM-AdapSS-DE [9, 10]
pPOEMS	75	101	92	45	43	83	132	185	228	301	pPOEMS [17, 20]
Basic RCGA	**2.1**	3.7	3.6	33	38	143	335	641	849	1182	Basic RCGA [24]
SPSA	65	78	101	9123	7680	7652	7654	7639	*11e-1/1e5*	.	SPSA [13]

Table 21: Running time excess ERT/$\text{ERT}_{\text{best 2009}}$ on f_{21} in **2-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

21 Gallagher 101 peaks

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
ERT_{best}/D	0.50	0.50	0.83	25	87	138	145	153	162	165	ERT_{best}/D
(1,2)-CMA-ES	**1**	**1**	**1.3**	15	14	16	16	17	17	17	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	**1**	**1**	**1.6**	7.6	8.8	8.7	13	17	17	16	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	**1**	**1**	**1.8**	5.5	13	13	16	16	15	15	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	**1**	**1**	**1.5**	20	14	13	20	21	20	20	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	**1**	**1**	**1.4**	8.9	5.8	4.4	4.4	4.2	4.1	4.1	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	**1**	**1**	**1.6**	5.6	4.9	4.2	6.7	6.6	6.3	6.3	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	**1**	**1**	**1.4**	6.6	4.7	3.7	**3.6**	**3.4**	**3.3**	**3.5**	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	**1**	**1**	**1.4**	9.3	7.6	6.0	5.7	5.5	5.2	5.2	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	**1**	**1**	**1.6**	12	11	7.2	6.9	6.5	6.2	6.2	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	**1**	**1**	**1.3**	12	7.9	5.1	4.9	4.6	4.4	4.4	(1+2ms)-CMA-ES [2]
Artif Bee Colony	**1**	**1**	**1.2**	**2.0**	**1.8**	**2.6**	5.5	10	26	59	Artif Bee Colony [8]
avg NEWUOA	**1**	**1**	6.1	6.5	4.6	**2.9**	**2.8**	**2.7**	**2.6**	**2.7**	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	**1**	7.5	12	23	34	75	96	201	234	500	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	**1**	**1**	**1.3**	284	83	53	51	48	46	45	Adap DE (F-AUC) [10]
DE (Uniform)	**1**	**1**	**1.5**	**2.1**	**1.0**	**1.1**	**1.5**	**1.6**	**1.6**	**2.0**	DE (Uniform) [9]
IPOP-aCMA-ES	**1**	**1**	**1.5**	6.2	7.0	4.9	5.3	5.4	5.2	25	IPOP-aCMA-ES [16]
IPOP-CMA-ES	**1**	**1**	**1.3**	13	7.7	5.4	13	13	13	14	IPOP-CMA-ES [22]
CMA+DE-MOS	**1**	**1**	**1.5**	**1.8**	**4.3**	4.9	5.3	6.5	10	12	CMA+DE-MOS [18]
NBC-CMA	**1**	**1**	**0.96**	**2.3**	7.1	25	30	36	35	35	NBC-CMA [21]
POEMS	**1**	**1**	111	143	309	198	191	182	178	178	POEMS [17]
PM-AdapSS-DE	**1**	**1**	**1.7**	**1.7**	83	53	51	48	46	45	PM-AdapSS-DE [9, 10]
pPOEMS	**1**	**1**	**1.8**	17	8.0	14	25	44	60	105	pPOEMS [17, 20]
Basic RCGA	**1**	**1**	**1.4**	14	13	34	71	96	197	285	Basic RCGA [24]
SPSA	**1**	21	47	94	266	218	223	297	320	753	SPSA [13]

Table 22: Running time excess ERT/$\text{ERT}_{\text{best 2009}}$ on f_{22} in **2-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

22 Gallagher 21 peaks

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
ERT_{best}/D	0.50	0.50	2.5	13	84	109	125	142	144	153	ERT_{best}/D
(1,2)-CMA-ES	**1**	**1**	**2.1**	17	6.1	9.1	8.6	8.3	12	12	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	**1**	**1**	**1.4**	34	19	24	25	22	23	22	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	**1**	**1**	**1.3**	15	10	11	14	20	23	22	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	**1**	**1**	**1.6**	31	18	18	23	28	31	30	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	**1**	**1**	**2.2**	10	8.3	7.0	6.5	5.9	6.6	6.3	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	**1**	**1**	**1.6**	14	11	11	11	10	9.5	9.1	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	**1**	**1**	3.2	19	6.5	5.7	5.3	4.7	4.6	4.4	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	**1**	**1**	**1.5**	16	5.1	6.0	5.5	4.9	5.3	5.1	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	**1**	**1**	6.6	19	4.4	3.6	3.3	**3.0**	**3.0**	**2.9**	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	**1**	**1**	**1**	8.5	4.4	**3.5**	**3.2**	**2.8**	**2.8**	**2.7**	(1+2ms)-CMA-ES [2]
Artif Bee Colony	**1**	**1**	**1.4**	**2.7**	**2.8**	4.2	8.9	21	47	373	Artif Bee Colony [8]
avg NEWUOA	**1**	**1**	**3.0**	3.8	**1.3**	**1.1**	**1.1**	**1.1**	**1.1**	**1.3**	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	**1**	8.5	4.8	12	34	50	119	184	274	760	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	**1**	**1**	**1.9**	**2.2**	184	143	125	110	108	103	Adap DE (F-AUC) [10]
DE (Uniform)	**1**	**1**	**1.3**	**2.2**	**1.0**	**1.3**	**1.5**	**1.7**	**1.8**	**2.2**	DE (Uniform) [9]
IPOP-aCMA-ES	**1**	**1**	**1.2**	4.7	5.5	4.7	7.7	7.2	7.2	15	IPOP-aCMA-ES [16]
IPOP-CMA-ES	**1**	**1**	**1.6**	5.9	5.0	5.0	4.8	5.3	23	72	IPOP-CMA-ES [22]
CMA+DE-MOS	**1**	**1**	**1.2**	3.7	**2.9**	3.8	4.7	5.2	6.2	8.4	CMA+DE-MOS [18]
NBC-CMA	**1**	**1**	**1.3**	**2.2**	8.4	21	31	28	28	28	NBC-CMA [21]
POEMS	**1**	**1**	66	31	604	467	412	365	364	350	POEMS [17]
PM-AdapSS-DE	**1**	**1**	**1.5**	**2.4**	86	67	59	52	51	49	PM-AdapSS-DE [9, 10]
pPOEMS	**1**	**1**	39	26	17	32	44	58	70	129	pPOEMS [17, 20]
Basic RCGA	**1**	**1**	**1.4**	**2.1**	11	25	69	119	232	604	Basic RCGA [24]
SPSA	**1**	22	107	284	373	750	1930	9991	9800	*38e-4/1e5*	SPSA [13]

Table 23: Running time excess ERT/ERT$_{\text{best 2009}}$ on f_{23} in **2-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

23 Katsuuras

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
ERT$_{\text{best}}$/D	0.50	0.50	3.9	96	117	131	150	157	174	190	ERT$_{\text{best}}$/D
(1,2)-CMA-ES	**1**	**1**	**1.5**	22	214	253	222	213	192	243	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	**1**	**1**	4.2	10	76	81	71	68	62	57	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	**1**	**1**	**2.2**	18	90	99	90	86	78	72	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	**1**	**1**	**1.6**	14	103	225	288	276	249	770	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	**1**	**1**	**2.1**	11	23	23	27	26	24	22	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	**1**	**1**	3.8	13	19	17	15	15	13	13	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	**1**	**1**	4.5	8.5	13	13	12	**12**	**11**	**10**	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	**1**	**1**	**2.2**	14	29	29	26	25	22	21	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	**1**	**1**	8.2	3.1	**4.5**	**4.5**	**4.5**	**6.1**	**5.6**	**5.4**	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	**1**	**1**	**2.0**	**2.2**	6.7	14	14	13	**12**	**11**	(1+2ms)-CMA-ES [2]
Artif Bee Colony	**1**	**1**	**2.1**	15	1791	*13e-2/1e5*	.	.	.	.	Artif Bee Colony [8]
avg NEWUOA	**1**	**1**	4.2	6.7	25	103	262	*49e-3/6e3*	.	.	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	**1**	**2.5**	4.0	12	2604	*17e-2/1e5*	.	.	.	.	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	**1**	**1**	**1.8**	**2.4**	**5.4**	**7.6**	**9.3**	**11**	13	15	Adap DE (F-AUC) [10]
DE (Uniform)	**1**	**1**	**2.5**	**2.3**	6.0	**8.2**	10	12	13	16	DE (Uniform) [9]
IPOP-aCMA-ES	**1**	**1**	**2.8**	6.6	16	19	17	16	15	14	IPOP-aCMA-ES [16]
IPOP-CMA-ES	**1**	**1**	**1.9**	7.8	162	233	204	196	177	162	IPOP-CMA-ES [22]
CMA+DE-MOS	**1**	**1**	**2.0**	5.5	24	40	44	46	43	42	CMA+DE-MOS [18]
NBC-CMA	**1**	**1**	**1.8**	10	737	761	668	639	576	529	NBC-CMA [21]
POEMS	**1**	**1**	13	41	253	245	233	234	225	230	POEMS [17]
PM-AdapSS-DE	**1**	**1**	**2.0**	**1.9**	**5.8**	8.5	**10**	12	13	16	PM-AdapSS-DE [9, 10]
pPOEMS	**1**	**1**	11	61	659	866	996	1160	1199	1404	pPOEMS [17, 20]
Basic RCGA	**1**	**1**	**1.9**	5.2	256	889	4692	4487	*29e-3/5e4*	.	Basic RCGA [24]
SPSA	**1**	13	18	264	*49e-2/1e5*	.	.	.	.	.	SPSA [13]

Table 24: Running time excess ERT/ERT$_{\text{best 2009}}$ on f_{24} in **2-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

24 Lunacek bi-Rastrigin

Δftarget ERT$_{\text{best}}$/D	1e+03 0.50	1e+02 0.50	1e+01 9.1	1e+00 429	1e-01 4257	1e-02 11700	1e-03 12056	1e-04 12360	1e-05 12360	1e-07 12360	Δftarget ERT$_{\text{best}}$/D
(1,2)-CMA-ES	**1**	**1**	6.6	12	*40e-2/1e4*	.	.	.	.	.	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	**1**	**1**	**1.5**	5.7	35	*43e-2/1e4*	.	.	.	.	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	**1**	**1**	**1.3**	7.8	33	*46e-2/1e4*	.	.	.	.	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	**1**	**1**	**2.3**	19	35	13	12	12	12	12	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	**1**	**1**	**1.2**	8.6	17	*22e-2/1e4*	.	.	.	.	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	**1**	**1**	**2.4**	4.6	**3.3**	5.8	5.7	5.5	5.5	5.5	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	**1**	**1**	**2.8**	5.9	5.7	**3.9**	**3.8**	**3.7**	**3.7**	**3.7**	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	**1**	**1**	**1.6**	4.9	7.8	12	12	12	12	12	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	**1**	**1**	36	6.0	7.5	**2.7**	**2.6**	**2.6**	**2.6**	**2.6**	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	**1**	**1**	4.2	**4.0**	**5.3**	12	12	12	12	12	(1+2ms)-CMA-ES [2]
Artif Bee Colony	**1**	**1**	**2.1**	4.2	16	122	*62e-3/1e5*	.	.	.	Artif Bee Colony [8]
avg NEWUOA	**1**	**1**	3.3	**1.9**	**1.4**	6.2	6.0	5.9	5.9	5.9	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	19	19	3.9	48	60	*16e-2/1e5*	.	.	.	.	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	**1**	**1**	**1.5**	934	94	34	33	32	32	32	Adap DE (F-AUC) [10]
DE (Uniform)	**1**	**1**	**2.2**	351	35	17	17	16	16	16	DE (Uniform) [9]
IPOP-aCMA-ES	**1**	**1**	**1.6**	80	374	477	463	452	452	452	IPOP-aCMA-ES [16]
IPOP-CMA-ES	**1**	**1**	**1.2**	27	375	*31e-2/4e5*	.	.	.	.	IPOP-CMA-ES [22]
CMA+DE-MOS	**1**	**1**	**1.7**	**3.7**	6.5	**3.1**	**3.9**	**4.1**	**4.2**	**5.0**	CMA+DE-MOS [18]
NBC-CMA	**1**	**1**	**1.9**	48	32	24	28	37	37	37	NBC-CMA [21]
POEMS	**1**	**1**	28	4554	481	176	171	167	167	167	POEMS [17]
PM-AdapSS-DE	**1**	**1**	**1.8**	351	35	13	13	12	12	12	PM-AdapSS-DE [9, 10]
pPOEMS	**1**	**1.1**	23	507	56	27	27	27	28	29	pPOEMS [17, 20]
Basic RCGA	**1**	**1**	**2.4**	73	78	61	59	58	58	58	Basic RCGA [24]
SPSA	41	51	1717	*31e-1/1e5*	.	.	.	.	.	.	SPSA [13]

Table 25: Running time excess ERT/$\mathrm{ERT}_{\text{best 2009}}$ on f_1 in **3-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

1 Sphere

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
$\mathrm{ERT}_{\text{best}}$/D	0.33	0.33	1.2	2.7	2.7	2.7	2.7	2.7	2.7	2.7	$\mathrm{ERT}_{\text{best}}$/D
(1,2)-CMA-ES	**1**	**1**	6.3	9.3	16	26	31	40	46	66	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	**1**	**1**	**2.9**	5.2	12	18	24	31	38	51	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	**1**	**1**	**1.9**	4.0	8.2	13	19	23	30	41	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	**1**	**1**	5.5	6.7	12	19	28	34	42	60	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	**1**	**1**	3.1	4.5	10	14	19	24	29	37	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	**1**	**1.1**	3.4	4.5	8.3	12	17	22	27	35	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	**1**	**1**	**2.4**	**3.4**	**5.8**	**8.8**	**12**	**15**	**20**	**26**	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	**1**	**1.2**	**2.7**	**3.7**	**6.7**	**11**	**14**	**18**	24	30	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	**1**	**1**	**2.3**	3.9	8.8	12	16	20	23	31	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	**1**	**1**	**2.9**	4.8	8.4	12	15	19	**23**	**29**	(1+2ms)-CMA-ES [2]
Artif Bee Colony	**1**	**1**	5.4	20	41	64	88	118	147	210	Artif Bee Colony [8]
avg NEWUOA	**1**	**1.3**	**2.4**	**1.1**	**1.1**	**1.1**	**1.1**	**1.1**	**1.1**	**1.1**	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	**1.1**	23	13	14	24	40	69	107	139	197	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	**1**	**1.1**	**2.4**	15	33	53	76	96	118	163	Adap DE (F-AUC) [10]
DE (Uniform)	**1**	**1**	3.4	14	35	57	79	105	126	174	DE (Uniform) [9]
IPOP-aCMA-ES	**1**	**1**	3.6	6.4	11	16	23	28	33	44	IPOP-aCMA-ES [16]
IPOP-CMA-ES	**1**	**1**	3.6	4.9	11	18	23	30	35	47	IPOP-CMA-ES [22]
CMA+DE-MOS	**1**	**1.1**	**2.5**	18	48	72	100	128	152	208	CMA+DE-MOS [18]
NBC-CMA	**1**	**1**	**2.3**	16	45	57	66	79	90	112	NBC-CMA [21]
POEMS	**1**	**1**	173	108	191	479	961	1309	1628	2506	POEMS [17]
PM-AdapSS-DE	**1**	**1.4**	**2.4**	16	33	55	77	99	120	166	PM-AdapSS-DE [9, 10]
pPOEMS	**1**	**1**	49	90	165	1519	3923	6568	9419	15398	pPOEMS [17, 20]
Basic RCGA	**1**	**1.1**	**2.0**	20	77	152	268	497	693	1315	Basic RCGA [24]
SPSA	**1**	33	19	11	14	17	20	24	27	34	SPSA [13]

Table 26: Running time excess ERT/ERT$_{\text{best 2009}}$ on f_2 in **3-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

2 Ellipsoid separable

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
ERT$_{\text{best}}$/D	6.0	11	13	14	14	15	15	15	16	16	ERT$_{\text{best}}$/D
(1,2)-CMA-ES	22	27	45	52	62	63	64	64	65	65	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	27	24	39	47	50	51	52	53	54	55	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	20	26	33	40	44	44	45	44	45	46	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	36	63	97	114	111	111	114	112	112	114	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	11	11	16	21	23	24	24	25	25	26	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	10	14	19	22	23	23	24	24	24	25	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	9.2	10	12	14	**14**	**15**	**16**	**16**	**16**	**17**	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	8.3	6.3	11	17	19	19	20	20	21	21	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	**7.1**	**6.3**	**10**	**12**	**12**	**13**	**13**	**13**	**14**	**15**	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	**6.7**	**5.2**	**8.4**	**10**	**10**	**11**	**11**	**12**	**12**	**13**	(1+2ms)-CMA-ES [2]
Artif Bee Colony	15	12	18	20	29	37	43	51	53	64	Artif Bee Colony [8]
avg NEWUOA	**1**	**0.92**	**1.7**	**8.2**	14	21	30	36	43	57	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	63	85	109	115	112	161	168	168	167	171	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	13	11	14	16	20	23	27	30	33	38	Adap DE (F-AUC) [10]
DE (Uniform)	12	13	15	18	22	26	30	32	36	43	DE (Uniform) [9]
IPOP-aCMA-ES	8.1	8.0	11	13	14	15	16	16	17	18	IPOP-aCMA-ES [16]
IPOP-CMA-ES	11	9.0	12	17	17	18	20	20	21	22	IPOP-CMA-ES [22]
CMA+DE-MOS	19	18	22	27	34	39	45	51	58	67	CMA+DE-MOS [18]
NBC-CMA	18	18	21	31	39	45	53	54	55	57	NBC-CMA [21]
POEMS	149	187	262	318	368	468	508	561	630	715	POEMS [17]
PM-AdapSS-DE	11	12	14	17	21	25	29	31	35	41	PM-AdapSS-DE [9, 10]
pPOEMS	220	327	861	1222	2034	2503	3069	3489	3943	4434	pPOEMS [17, 20]
Basic RCGA	27	32	71	124	166	221	317	391	744	1950	Basic RCGA [24]
SPSA	2887	10773	1.12e5	*95e+0/1e5*	.	.	.	.	.	.	SPSA [13]

Table 27: Running time excess ERT/ERT$_{\text{best 2009}}$ on f_3 in **3-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

3 Rastrigin separable

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
ERT$_{\text{best}}$/D	0.33	0.73	13	274	277	278	281	282	282	284	ERT$_{\text{best}}$/D
(1,2)-CMA-ES	**1.3**	4.5	50	60	252	250	248	248	247	246	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	**1.4**	**2.7**	**4.1**	16	108	108	107	107	107	106	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	**1.2**	**2.4**	8.5	10	101	126	125	124	124	123	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	**1.1**	6.2	62	78	*20e-1 /1e4*	.	.	.	.	.	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	**1**	4.2	10	8.0	40	39	39	39	39	39	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	**1.1**	**2.6**	7.5	7.6	36	41	41	41	41	41	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	**1.2**	**2.4**	6.6	10	42	42	42	42	42	41	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	**1**	**2.6**	9.3	12	58	58	58	58	57	57	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	**1.5**	3.0	8.9	14	95	95	94	94	94	93	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	**1.1**	3.3	14	6.1	47	47	46	46	46	46	(1+2ms)-CMA-ES [2]
Artif Bee Colony	**1.1**	**2.3**	**5.8**	**1.1**	**1.8**	**2.4**	**2.8**	**3.4**	**3.7**	**4.4**	Artif Bee Colony [8]
avg NEWUOA	**1**	4.4	9.4	5.0	33	33	33	33	33	32	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	7.5	15	89	343	813	819	1018	1434	1430	1421	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	**1**	**2.4**	6.6	**2.5**	**3.5**	**4.0**	**4.2**	**4.3**	**4.6**	**4.9**	Adap DE (F-AUC) [10]
DE (Uniform)	**1.1**	**1.3**	8.7	**2.9**	135	135	134	134	134	133	DE (Uniform) [9]
IPOP-aCMA-ES	**1.1**	3.5	**3.0**	**2.7**	13	17	17	17	17	18	IPOP-aCMA-ES [16]
IPOP-CMA-ES	**1.1**	3.7	7.5	3.4	25	33	34	34	35	36	IPOP-CMA-ES [22]
CMA+DE-MOS	**1.1**	**2.3**	10	**1.7**	**2.6**	**3.2**	**3.6**	**4.0**	**4.4**	**5.1**	CMA+DE-MOS [18]
NBC-CMA	**1.1**	**2.1**	9.2	5.9	31	31	31	31	31	31	NBC-CMA [21]
POEMS	33	227	28	7.8	24	28	31	35	38	46	POEMS [17]
PM-AdapSS-DE	**1.5**	**2.2**	7.8	**2.5**	29	59	59	59	59	59	PM-AdapSS-DE [9, 10]
pPOEMS	**1.2**	43	30	20	60	87	125	151	174	235	pPOEMS [17, 20]
Basic RCGA	**1**	**2.2**	21	22	36	52	64	66	68	71	Basic RCGA [24]
SPSA	97	9807	4164	*25e-1 /1e5*	.	.	.	.	.	.	SPSA [13]

Table 28: Running time excess ERT/ERT$_{\text{best 2009}}$ on f_4 in **3-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

4 Skew Rastrigin-Bueche separ

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
ERT$_{\text{best}}$/D	0.33	1.8	13	269	289	307	317	330	338	348	ERT$_{\text{best}}$/D
(1,2)-CMA-ES	**2.5**	3.9	34	68	*20e-1/1e4*	.	.	.	.	.	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	**1.6**	**1.7**	25	22	153	144	139	134	131	127	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	**1.1**	**2.1**	26	38	235	221	214	206	201	196	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	**1.3**	**2.2**	67	166	494	465	450	433	422	411	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	**1.7**	**1.3**	18	18	109	103	99	96	93	91	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	**1.5**	**1.4**	11	**10**	121	113	110	106	103	100	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	**1.2**	**1.0**	**9.4**	23	71	67	65	62	61	59	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	**1.8**	**2.2**	26	20	57	54	52	50	49	**48**	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	**2.1**	**1.9**	36	32	236	222	215	207	201	196	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	**1.5**	**1.3**	20	16	63	59	57	55	54	52	(1+2ms)-CMA-ES [2]
Artif Bee Colony	**1.3**	**1.3**	**6.5**	**1.7**	**2.6**	**3.0**	**3.5**	**3.9**	**4.4**	**5.2**	Artif Bee Colony [8]
avg NEWUOA	**2.9**	9.2	11	14	162	153	148	142	139	135	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	14	7.7	665	*42e-1/1e5*	.	.	.	.	.	.	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	**1.5**	**1.4**	11	252	1390	1307	1265	1217	1187	1155	Adap DE (F-AUC) [10]
DE (Uniform)	**1.2**	**1.5**	11	31	524	493	477	460	448	436	DE (Uniform) [9]
IPOP-aCMA-ES	**1.9**	**2.2**	**8.2**	463	*92e-2/2e5*	.	.	.	.	.	IPOP-aCMA-ES [16]
IPOP-CMA-ES	**1.8**	**2.4**	12	440	4534	4262	4124	3969	3869	3763	IPOP-CMA-ES [22]
CMA+DE-MOS	**1.7**	**1.4**	11	**2.3**	**5.6**	**5.8**	**6.0**	**6.2**	**6.5**	**7.0**	CMA+DE-MOS [18]
NBC-CMA	**1.3**	**2.4**	12	28	104	98	95	91	89	87	NBC-CMA [21]
POEMS	105	116	43	17	**41**	**42**	**43**	**46**	**48**	53	POEMS [17]
PM-AdapSS-DE	**2.0**	**1.5**	12	200	958	901	872	840	836	814	PM-AdapSS-DE [9, 10]
pPOEMS	**1.3**	51	41	35	66	107	122	149	163	211	pPOEMS [17, 20]
Basic RCGA	**1.5**	**1.2**	31	2636	*11e-1/5e4*	.	.	.	.	.	Basic RCGA [24]
SPSA	24	8590	11838	*11e+0/1e5*	.	.	.	.	.	.	SPSA [13]

Table 29: Running time excess ERT/$\text{ERT}_{\text{best 2009}}$ on f_5 in **3-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

5 Linear slope

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
ERT_{best}/D	0.33	0.33	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	ERT_{best}/D
(1,2)-CMA-ES	**1**	**1.7**	4.1	7.1	7.5	7.7	7.7	7.7	7.7	7.7	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	**1**	**1.2**	**2.6**	4.0	4.1	4.2	4.2	4.2	4.2	4.2	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	**1**	**1.3**	**2.0**	**3.2**	**3.2**	**3.2**	**3.2**	**3.2**	**3.2**	**3.2**	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	**1**	**1.1**	4.6	8.0	8.4	8.4	8.5	8.5	8.5	8.5	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	**1**	**1.7**	3.0	5.4	5.6	5.7	5.7	5.7	5.7	5.7	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	**1**	**1.3**	**2.5**	3.7	3.7	3.8	3.8	3.8	3.8	3.8	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	**1**	**1.1**	**1.5**	**2.6**	**2.7**	**2.7**	**2.7**	**2.7**	**2.7**	**2.7**	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	**1**	**1.6**	**2.7**	3.6	3.8	3.8	3.8	3.8	3.8	3.8	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	**1**	**1**	**2.3**	3.7	3.9	3.9	3.9	3.9	3.9	3.9	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	**1**	**1.8**	**2.4**	4.0	4.0	4.0	4.0	4.0	4.0	4.0	(1+2ms)-CMA-ES [2]
Artif Bee Colony	**1**	**1.5**	15	31	35	35	35	35	35	35	Artif Bee Colony [8]
avg NEWUOA	**1**	**1.5**	**1.3**	**1.5**	**1.5**	**1.5**	**1.5**	**1.5**	**1.5**	**1.5**	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	**1**	10	5.1	7.6	8.0	8.0	8.0	8.0	8.0	8.0	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	**1**	**1.2**	8.7	16	17	17	17	17	17	17	Adap DE (F-AUC) [10]
DE (Uniform)	**1**	**1.3**	6.5	18	20	20	20	20	20	20	DE (Uniform) [9]
IPOP-aCMA-ES	**1**	**1**	3.3	6.0	6.4	6.4	6.4	6.4	6.4	6.4	IPOP-aCMA-ES [16]
IPOP-CMA-ES	**1**	**1.3**	3.4	5.7	5.7	5.7	5.7	5.7	5.7	5.7	IPOP-CMA-ES [22]
CMA+DE-MOS	**1**	**1.3**	10	23	35	35	35	35	35	35	CMA+DE-MOS [18]
NBC-CMA	**1**	**1.3**	19	50	52	52	52	52	52	52	NBC-CMA [21]
POEMS	**1**	19	117	152	173	185	186	186	186	186	POEMS [17]
PM-AdapSS-DE	**1**	**1.4**	6.4	18	19	19	20	20	20	20	PM-AdapSS-DE [9, 10]
pPOEMS	**1**	**1.1**	110	144	170	178	184	185	186	186	pPOEMS [17, 20]
Basic RCGA	**1**	**1.3**	148	664	1102	1568	1996	4562	29702	*11e-6/5e4*	Basic RCGA [24]
SPSA	**1**	15	11	19	20	20	20	20	20	20	SPSA [13]

Table 30: Running time excess ERT/$\text{ERT}_{\text{best 2009}}$ on f_6 in **3-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

6 Attractive sector

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
ERT_{best}/D	1.4	2.5	11	19	30	39	50	61	72	88	ERT_{best}/D
(1,2)-CMA-ES	4.0	3.3	5.0	7.6	6.3	6.1	5.8	5.3	5.0	5.5	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	**2.7**	**2.6**	3.8	4.4	4.1	4.4	4.8	4.4	4.1	4.1	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	**2.3**	**2.0**	**2.9**	3.5	3.5	3.7	3.4	3.3	3.4	3.4	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	3.2	4.6	8.2	8.4	6.9	8.0	7.5	6.8	6.8	7.2	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	**3.0**	**2.7**	**1.9**	**2.5**	**2.3**	**2.4**	**2.5**	**2.3**	**2.4**	**2.5**	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	**2.3**	**1.9**	**2.3**	**2.7**	**2.6**	**2.6**	**2.6**	**2.3**	**2.4**	**2.5**	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	**2.1**	**1.7**	**1.5**	**1.8**	**1.8**	**1.8**	**1.7**	**1.8**	**1.7**	**1.7**	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	4.0	**2.5**	**1.7**	**2.1**	**1.9**	**2.0**	**1.9**	**2.0**	**2.0**	**2.2**	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	**1.7**	**2.4**	**1.6**	**2.0**	**1.9**	**1.9**	**1.8**	**1.8**	**1.8**	**1.9**	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	**1.9**	**1.6**	**1.8**	**2.0**	**1.7**	**1.7**	**1.6**	**1.5**	**1.5**	**1.6**	(1+2ms)-CMA-ES [2]
Artif Bee Colony	3.4	**2.2**	3.8	13	43	163	445	490	592	524	Artif Bee Colony [8]
avg NEWUOA	**1.2**	**2.3**	**2.6**	**2.9**	**2.9**	3.8	3.9	4.1	4.3	4.7	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	7.3	74	115	312	207	488	608	526	603	2355	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	4.9	**2.8**	5.3	8.8	8.9	9.0	8.9	9.1	8.7	9.5	Adap DE (F-AUC) [10]
DE (Uniform)	3.6	4.1	4.3	9.2	9.5	10	10	10	10	10	DE (Uniform) [9]
IPOP-aCMA-ES	4.0	4.3	3.3	3.3	3.2	3.3	3.2	**2.9**	**3.0**	3.0	IPOP-aCMA-ES [16]
IPOP-CMA-ES	3.9	**2.8**	**2.8**	3.3	3.3	3.3	3.2	**3.0**	**3.0**	3.1	IPOP-CMA-ES [22]
CMA+DE-MOS	4.2	3.4	5.8	14	13	15	14	13	13	14	CMA+DE-MOS [18]
NBC-CMA	6.0	3.5	4.5	14	11	9.3	8.4	7.6	7.2	6.9	NBC-CMA [21]
POEMS	150	84	34	61	83	92	101	95	96	109	POEMS [17]
PM-AdapSS-DE	5.1	3.3	3.7	8.6	8.7	9.2	9.4	9.3	9.4	10	PM-AdapSS-DE [9, 10]
pPOEMS	89	74	37	228	455	618	631	670	717	803	pPOEMS [17, 20]
Basic RCGA	23	14	13	160	302	813	1494	3510	4760	*18e-4/5e4*	Basic RCGA [24]
SPSA	23	4689	11501	11802	14416	*11e+0/1e5*	.	.	.	.	SPSA [13]

Table 31: Running time excess ERT/ERT$_{\text{best 2009}}$ on f_7 in **3-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

7 Step-ellipsoid

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
ERT$_{\text{best}}$/D	0.33	0.87	3.8	22	114	155	161	161	161	178	ERT$_{\text{best}}$/D
(1,2)-CMA-ES	**1.3**	3.4	15	11	17	83	202	202	202	256	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	**1.5**	3.2	3.4	6.8	8.0	20	27	27	27	51	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	**1.3**	**2.4**	3.9	3.4	5.2	25	44	44	44	59	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	**1.1**	**2.1**	6.9	18	17	107	179	179	179	389	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	**1.3**	4.8	3.9	**2.2**	3.1	3.4	6.7	6.7	6.7	16	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	**1.3**	**2.1**	**2.2**	**2.1**	**1.9**	3.3	3.2	3.2	3.2	3.9	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	**1.4**	**1.9**	14	3.8	**1.6**	**2.2**	3.9	3.9	3.9	6.8	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	**1.2**	**2.5**	3.4	**2.6**	**2.6**	3.3	5.6	5.6	5.6	10	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	**1.9**	**1.7**	**2.7**	**1.9**	**0.82**	**2.2**	**2.5**	**2.5**	**2.5**	**2.3**	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	**1.5**	**2.1**	**2.2**	**2.2**	**1.3**	**1.3**	**1.5**	**1.5**	**1.5**	**1.4**	(1+2ms)-CMA-ES [2]
Artif Bee Colony	**1.2**	**1.6**	6.1	8.0	10	22	85	85	85	125	Artif Bee Colony [8]
avg NEWUOA	**1.3**	3.5	**1.2**	6.8	4.8	19	41	41	41	37	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	17	164	246	781	2492	9087	8751	8751	8751	7880	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	**1.3**	**1.5**	**2.4**	3.4	**1.1**	**1.2**	**1.4**	**1.4**	**1.4**	**1.5**	Adap DE (F-AUC) [10]
DE (Uniform)	**1.3**	**1.5**	5.5	4.2	**1.3**	**1.4**	**1.6**	**1.6**	**1.6**	**1.6**	DE (Uniform) [9]
IPOP-aCMA-ES	**1.3**	**2.6**	**2.9**	**1.7**	**0.93**	**0.90**	**1.0**	**1.0**	**1.0**	**1.1**	IPOP-aCMA-ES [16]
IPOP-CMA-ES	**1.5**	**2.4**	3.5	7.2	**2.0**	**1.6**	**1.9**	**1.9**	**1.9**	**1.8**	IPOP-CMA-ES [22]
CMA+DE-MOS	**1.1**	**2.2**	3.0	4.4	**2.3**	**2.2**	**2.3**	**2.3**	**2.3**	**2.4**	CMA+DE-MOS [18]
NBC-CMA	**1.1**	**2.2**	4.2	4.9	**2.5**	**2.2**	**2.2**	**2.2**	**2.2**	**2.1**	NBC-CMA [21]
POEMS	92	240	76	28	27	26	28	28	28	28	POEMS [17]
PM-AdapSS-DE	**1.5**	**1.8**	4.3	3.5	**1.2**	**1.3**	**1.6**	**1.6**	**1.6**	**1.6**	PM-AdapSS-DE [9, 10]
pPOEMS	**1.6**	33	61	30	40	67	91	91	91	106	pPOEMS [17, 20]
Basic RCGA	**1.1**	**2.1**	5.6	43	80	161	212	212	212	208	Basic RCGA [24]
SPSA	59	193	20672	30144	*69e-1 /1e5*	.	.	.	.	.	SPSA [13]

Table 32: Running time excess ERT/$\text{ERT}_{\text{best 2009}}$ on f_8 in **3-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

8 Rosenbrock original

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
ERT_{best}/D	1.4	4.9	9.1	15	51	60	63	65	66	69	ERT_{best}/D
(1,2)-CMA-ES	5.0	10	12	28	16	17	18	18	18	18	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	**2.8**	**2.2**	10	20	9.3	10	11	11	11	11	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	**2.6**	6.2	12	29	12	12	13	13	13	13	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	**1.8**	**2.2**	3.9	50	23	25	28	29	29	29	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	4.4	4.3	3.8	11	5.3	5.4	5.7	5.9	6.0	6.2	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	3.9	3.3	3.5	13	6.7	6.7	6.8	6.8	6.9	7.0	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	**2.4**	**2.6**	3.5	10	4.3	4.4	4.6	4.6	4.7	4.8	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	**2.5**	**1.6**	**2.0**	10	5.0	5.4	5.7	5.7	5.8	5.8	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	**2.5**	**2.6**	**2.5**	**6.5**	**2.9**	**3.0**	**3.0**	**3.1**	**3.2**	**3.4**	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	**1.7**	**1.7**	**2.1**	**4.8**	**2.3**	**2.3**	**2.5**	**2.5**	**2.7**	**2.8**	(1+2ms)-CMA-ES [2]
Artif Bee Colony	**2.1**	3.9	3.8	17	26	235	3088	21956	*12e-4/1e5*	.	Artif Bee Colony [8]
avg NEWUOA	3.1	**1.9**	**1.9**	**2.6**	**1.0**	**0.98**	**0.98**	**1.00**	**1.0**	**1.0**	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	35	17	25	50	21	22	22	22	24	25	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	3.5	4.7	9.1	13	7.2	7.9	8.5	9.1	10	11	Adap DE (F-AUC) [10]
DE (Uniform)	5.1	5.2	8.4	16	9.5	11	12	13	14	15	DE (Uniform) [9]
IPOP-aCMA-ES	3.6	4.1	3.5	7.4	3.8	4.1	4.2	4.3	4.5	4.7	IPOP-aCMA-ES [16]
IPOP-CMA-ES	3.8	4.6	4.9	13	5.8	5.7	5.8	5.9	6.2	6.3	IPOP-CMA-ES [22]
CMA+DE-MOS	3.4	6.1	11	19	12	13	13	14	15	16	CMA+DE-MOS [18]
NBC-CMA	4.9	5.8	8.8	13	6.8	7.3	7.9	8.1	8.4	8.9	NBC-CMA [21]
POEMS	147	55	44	88	55	74	163	283	300	380	POEMS [17]
PM-AdapSS-DE	**2.2**	4.5	8.7	13	7.0	8.7	10	56	56	54	PM-AdapSS-DE [9, 10]
pPOEMS	125	53	43	148	221	376	479	643	794	1066	pPOEMS [17, 20]
Basic RCGA	**2.6**	7.0	13	61	640	1150	3462	*14e-3/5e4*	.	.	Basic RCGA [24]
SPSA	490	275	267	8639	5825	24022	*12e-1/1e5*	.	.	.	SPSA [13]

Table 33: Running time excess ERT/$\text{ERT}_{\text{best 2009}}$ on f_9 in **3-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

9 Rosenbrock rotated

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
ERT_{best}/D	0.33	0.33	6.9	22	42	50	53	55	56	59	ERT_{best}/D
(1,2)-CMA-ES	15	86	11	14	16	17	18	18	18	19	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	15	42	5.2	10	10	11	11	12	12	12	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	**7.8**	39	16	17	13	13	13	14	13	14	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	10	54	4.8	6.7	16	21	22	24	24	25	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	10	37	4.2	7.4	6.4	6.6	6.9	7.0	7.2	7.2	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	11	36	3.1	3.8	4.1	4.6	5.0	5.2	5.4	5.6	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	9.4	**23**	**2.5**	**3.1**	3.5	3.9	4.1	4.2	4.3	4.4	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	11	39	**2.7**	9.1	7.2	7.3	7.3	7.3	7.3	7.3	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	10	31	**2.6**	**3.3**	**2.9**	**3.1**	**3.1**	**3.3**	**3.4**	**3.6**	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	11	26	**2.8**	3.9	**3.3**	**3.3**	**3.4**	**3.5**	**3.6**	**3.7**	(1+2ms)-CMA-ES [2]
Artif Bee Colony	11	54	5.2	7.3	93	473	4854	26815	*24e-4/1e5*	.	Artif Bee Colony [8]
avg NEWUOA	11	**20**	**1.7**	**1.7**	**1.2**	**1.1**	**1.1**	**1.1**	**1.2**	**1.2**	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	125	163	26	37	29	27	27	28	28	29	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	14	42	7.7	10	9.3	11	19	22	24	24	Adap DE (F-AUC) [10]
DE (Uniform)	11	45	9.2	9.1	10	12	13	14	14	15	DE (Uniform) [9]
IPOP-aCMA-ES	10	38	3.5	5.9	4.8	4.8	5.1	5.3	5.4	5.6	IPOP-aCMA-ES [16]
IPOP-CMA-ES	**5.5**	**19**	**3.0**	4.8	4.4	4.8	5.0	5.2	5.5	5.7	IPOP-CMA-ES [22]
CMA+DE-MOS	10	55	11	4.9	6.9	9.3	10	11	12	14	CMA+DE-MOS [18]
NBC-CMA	8.8	56	10	9.1	8.7	9.3	10	10	10	11	NBC-CMA [21]
POEMS	603	753	55	213	138	176	252	352	461	604	POEMS [17]
PM-AdapSS-DE	**7.7**	31	7.6	8.4	8.4	10	10	11	12	13	PM-AdapSS-DE [9, 10]
pPOEMS	466	780	59	146	322	466	624	763	945	1276	pPOEMS [17, 20]
Basic RCGA	12	69	12	181	1567	7119	*94e-3/5e4*	.	.	.	Basic RCGA [24]
SPSA	5984	12372	1417	9774	*12e-1/1e5*	.	.	.	.	.	SPSA [13]

Table 34: Running time excess ERT/$\text{ERT}_{\text{best 2009}}$ on f_{10} in **3-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

10 Ellipsoid

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
ERT_{best}/D	10	18	38	51	56	60	65	69	73	81	ERT_{best}/D
(1,2)-CMA-ES	18	18	17	16	16	16	15	15	14	13	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	15	18	16	14	13	13	12	12	11	11	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	15	15	10	11	10	10	9.2	9.0	8.8	8.4	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	37	28	24	30	29	28	27	26	25	23	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	8.4	6.6	4.9	5.2	5.3	5.3	5.2	5.0	5.0	4.9	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	6.0	6.1	5.3	5.2	5.6	5.6	5.6	5.5	5.3	5.1	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	4.5	3.6	3.8	3.9	3.9	4.0	4.0	3.9	3.8	3.7	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	7.4	6.2	4.4	5.2	5.4	5.2	5.0	4.8	4.7	4.6	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	**4.1**	**3.5**	3.3	**3.1**	**3.2**	**3.2**	**3.1**	**3.1**	**3.1**	**3.0**	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	**4.3**	**3.5**	**3.0**	**2.7**	**2.8**	**2.9**	**2.9**	**2.8**	**2.8**	**2.8**	(1+2ms)-CMA-ES [2]
Artif Bee Colony	16	140	1203	27661	25935	*29e-1/1e5*	.	.	.	.	Artif Bee Colony [8]
avg NEWUOA	**1.1**	**1.3**	**1.9**	**3.4**	5.8	6.9	7.9	8.8	10	11	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	46	49	41	33	31	150	140	132	126	116	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	6.5	6.3	4.7	4.5	5.1	5.7	6.2	6.6	7.1	7.7	Adap DE (F-AUC) [10]
DE (Uniform)	6.3	6.6	5.0	4.7	5.3	6.0	6.7	7.1	7.5	8.4	DE (Uniform) [9]
IPOP-aCMA-ES	4.4	4.2	**3.1**	3.4	**3.5**	**3.6**	**3.5**	**3.5**	**3.5**	**3.5**	IPOP-aCMA-ES [16]
IPOP-CMA-ES	4.4	3.7	3.9	4.3	4.4	4.5	4.4	4.4	4.4	4.3	IPOP-CMA-ES [22]
CMA+DE-MOS	17	16	11	13	15	15	16	17	17	17	CMA+DE-MOS [18]
NBC-CMA	11	10	7.7	9.1	10	12	13	13	12	12	NBC-CMA [21]
POEMS	38	58	827	1937	4077	6368	10024	15191	30307	55197	POEMS [17]
PM-AdapSS-DE	5.8	6.4	4.8	4.6	5.4	5.9	6.6	7.1	7.4	8.2	PM-AdapSS-DE [9, 10]
pPOEMS	70	168	364	471	714	828	924	1041	1183	1304	pPOEMS [17, 20]
Basic RCGA	310	583	567	2411	13171	*25e-1/5e4*	.	.	.	.	Basic RCGA [24]
SPSA	1410	6302	17307	*84e+0/1e5*	.	.	.	.	.	.	SPSA [13]

Table 35: Running time excess ERT/ERT$_{\text{best 2009}}$ on f_{11} in **3-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

11 Discus

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
ERT$_{\text{best}}$/D	3.1	3.9	22	35	76	88	92	96	101	109	ERT$_{\text{best}}$/D
(1,2)-CMA-ES	10	74	36	27	14	12	12	12	12	11	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	18	80	28	23	12	10	10	10	10	9.4	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	16	44	20	19	9.5	8.5	8.3	8.2	8.2	8.0	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	34	119	36	36	19	17	17	17	16	15	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	5.2	18	10	8.8	4.7	4.3	4.3	4.3	4.2	4.2	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	4.2	24	12	9.3	4.7	4.3	4.3	4.3	4.3	4.2	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	6.7	11	7.0	6.9	3.6	3.2	3.1	3.1	3.1	3.0	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	**3.7**	15	9.3	7.5	4.0	3.7	3.6	3.6	3.6	3.5	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	**3.8**	13	5.9	5.3	**2.8**	**2.5**	**2.5**	**2.5**	**2.5**	**2.5**	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	3.9	**6.8**	**5.3**	**4.5**	**2.5**	**2.3**	**2.2**	**2.2**	**2.2**	**2.2**	(1+2ms)-CMA-ES [2]
Artif Bee Colony	7.0	**8.2**	28	262	2431	*14e-2/1e5*	.	.	.	.	Artif Bee Colony [8]
avg NEWUOA	**1.9**	**2.6**	**2.0**	**3.3**	**2.5**	**2.7**	3.3	3.7	4.3	5.0	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	12	172	78	59	29	25	24	24	23	23	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	13	20	5.7	5.5	3.0	3.4	3.7	4.3	4.6	5.3	Adap DE (F-AUC) [10]
DE (Uniform)	10	15	5.9	5.6	3.3	3.5	3.9	4.4	4.9	5.7	DE (Uniform) [9]
IPOP-aCMA-ES	6.1	9.1	**5.3**	**4.5**	**2.4**	**2.3**	**2.3**	**2.4**	**2.5**	**2.5**	IPOP-aCMA-ES [16]
IPOP-CMA-ES	6.0	13	9.2	7.5	4.0	3.7	3.7	3.7	3.7	3.7	IPOP-CMA-ES [22]
CMA+DE-MOS	13	23	17	17	8.8	8.5	8.7	9.0	9.0	9.4	CMA+DE-MOS [18]
NBC-CMA	11	25	11	16	9.1	8.8	9.2	9.1	9.0	9.1	NBC-CMA [21]
POEMS	79	81	138	716	641	891	1259	1627	1683	2371	POEMS [17]
PM-AdapSS-DE	11	17	6.1	5.6	3.4	3.6	4.1	4.5	4.9	5.6	PM-AdapSS-DE [9, 10]
pPOEMS	70	62	86	383	312	447	534	679	787	943	pPOEMS [17, 20]
Basic RCGA	11	17	342	1203	2947	8132	*58e-2/5e4*	.	.	.	Basic RCGA [24]
SPSA	10	224	3544	18559	*58e-1/1e5*	.	.	.	.	.	SPSA [13]

Table 36: Running time excess ERT/ERT$_{\text{best 2009}}$ on f_{12} in **3-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

12 Bent cigar

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
ERT$_{\text{best}}$/D	10	13	22	56	113	134	148	208	232	263	ERT$_{\text{best}}$/D
(1,2)-CMA-ES	23	43	55	39	27	28	27	23	22	21	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	5.9	11	25	16	11	10	10	8.2	8.1	8.1	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	10	15	25	17	11	10	9.4	7.3	6.9	6.7	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	18	51	96	90	60	55	52	50	46	67	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	4.7	8.9	19	13	8.0	7.4	7.2	5.4	5.2	5.2	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	4.4	8.8	17	12	7.9	7.3	7.1	5.5	5.3	5.1	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	**3.1**	**3.0**	13	10	6.8	6.4	6.2	4.9	4.7	4.6	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	3.1	**3.4**	**6.8**	7.2	5.6	5.6	5.5	4.3	4.2	4.2	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	**3.1**	3.8	10	**6.2**	**4.1**	**3.9**	**3.8**	**2.9**	**2.9**	**3.0**	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	3.1	3.6	10	7.9	5.1	5.0	4.7	**3.6**	**3.5**	**3.5**	(1+2ms)-CMA-ES [2]
Artif Bee Colony	10	18	53	283	1651	10641	*12e-2/1e5*	.	.	.	Artif Bee Colony [8]
avg NEWUOA	**1.1**	**1.9**	**4.5**	**3.2**	**2.2**	**2.2**	**2.2**	**1.8**	**1.8**	**1.9**	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	25	33	1357	1390	1873	2084	2726	3153	2827	2491	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	14	15	14	44	146	132	173	126	114	145	Adap DE (F-AUC) [10]
DE (Uniform)	16	16	14	8.1	227	277	251	246	221	196	DE (Uniform) [9]
IPOP-aCMA-ES	4.7	4.7	10	7.8	6.2	6.0	5.9	4.7	4.6	4.5	IPOP-aCMA-ES [16]
IPOP-CMA-ES	6.0	7.3	**8.9**	**6.6**	**4.5**	**4.6**	**4.6**	3.7	3.7	4.1	IPOP-CMA-ES [22]
CMA+DE-MOS	24	23	25	19	13	12	12	9.3	9.2	9.1	CMA+DE-MOS [18]
NBC-CMA	16	16	24	15	10	11	11	8.8	8.5	8.7	NBC-CMA [21]
POEMS	122	173	2189	3753	4466	5469	*22e-2/3e5*	.	.	.	POEMS [17]
PM-AdapSS-DE	14	17	344	284	229	505	456	360	324	286	PM-AdapSS-DE [9, 10]
pPOEMS	190	430	852	604	443	539	618	543	582	650	pPOEMS [17, 20]
Basic RCGA	41	42	592	577	414	1104	1141	3519	*96e-3/5e4*	.	Basic RCGA [24]
SPSA	3876	5174	7183	11674	12506	*21e+0/1e5*	.	.	.	.	SPSA [13]

Table 37: Running time excess ERT/ERT$_{\text{best 2009}}$ on f_{13} in **3-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

13 Sharp ridge

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
ERT$_{\text{best}}$/D	0.53	5.6	16	28	36	45	72	85	94	122	ERT$_{\text{best}}$/D
(1,2)-CMA-ES	**2.6**	7.3	21	29	27	29	26	23	24	41	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	**0.92**	**2.8**	17	26	33	32	25	31	36	56	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	**1.8**	4.2	15	19	21	22	20	19	28	72	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	**1.8**	7.8	17	45	47	47	37	46	67	91	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	**1.8**	**2.9**	6.6	8.1	8.7	7.9	6.1	6.9	6.9	8.1	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	**1**	3.1	5.2	8.6	8.2	7.8	5.9	7.0	7.1	7.6	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	**1.8**	**2.1**	**3.4**	**5.1**	5.9	6.1	**4.6**	5.3	6.3	6.9	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	**1.5**	**2.3**	7.3	7.7	7.6	7.2	5.6	5.8	6.0	5.5	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	**1.3**	**2.3**	4.1	7.7	6.9	6.6	5.2	5.2	5.0	6.0	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	**0.87**	3.6	5.2	5.1	**5.1**	**4.8**	**3.4**	**3.6**	**3.6**	**4.5**	(1+2ms)-CMA-ES [2]
Artif Bee Colony	**1.1**	6.7	12	160	3803	31398	*86e-3/1e5*	.	.	.	Artif Bee Colony [8]
avg NEWUOA	**2.5**	**1.0**	5.6	14	42	114	159	277	256	*36e-4/8e3*	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	17	8.4	1628	2638	18147	*61e-2/1e5*	.	.	.	.	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	**1.6**	5.8	7.4	7.7	8.6	8.8	7.0	7.1	7.3	7.2	Adap DE (F-AUC) [10]
DE (Uniform)	**1.4**	7.1	8.8	8.9	10	10	7.6	7.7	7.9	7.7	DE (Uniform) [9]
IPOP-aCMA-ES	**2.2**	**2.7**	**3.4**	**3.6**	**3.9**	**4.3**	**3.3**	**3.2**	**3.4**	**3.4**	IPOP-aCMA-ES [16]
IPOP-CMA-ES	**2.2**	3.0	**3.4**	**5.0**	**5.9**	**5.7**	4.6	**4.4**	**4.6**	**4.5**	IPOP-CMA-ES [22]
CMA+DE-MOS	**1.4**	4.5	14	15	15	15	11	11	11	10	CMA+DE-MOS [18]
NBC-CMA	**1.5**	7.9	9.5	9.1	12	12	8.8	8.7	8.7	8.6	NBC-CMA [21]
POEMS	191	48	67	1186	3456	4088	11632	*43e-4/3e5*	.	.	POEMS [17]
PM-AdapSS-DE	**2.0**	5.8	7.8	8.1	9.5	10	7.5	7.6	7.8	7.7	PM-AdapSS-DE [9, 10]
pPOEMS	**1.6**	51	101	595	922	1236	1020	1162	1390	1653	pPOEMS [17, 20]
Basic RCGA	**1.2**	10	115	440	1252	3765	5106	4324	3914	*46e-3/5e4*	Basic RCGA [24]
SPSA	21	34	110	2720	41486	*67e-2/1e5*	.	.	.	.	SPSA [13]

Table 38: Running time excess ERT/$\text{ERT}_{\text{best 2009}}$ on f_{14} in **3-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

14 Sum of different powers

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
ERT_{best}/D	0.33	0.33	0.73	5.8	9.5	14	24	31	37	65	ERT_{best}/D
(1,2)-CMA-ES	**1**	**1.2**	13	6.3	6.5	7.3	12	17	21	18	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	**1**	**1.1**	**1.6**	4.2	4.4	4.9	6.8	10	15	16	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	**1**	**1**	**2.3**	**2.5**	3.1	3.9	5.1	9.3	13	12	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	**1**	**1.3**	3.5	3.3	5.1	8.5	12	25	31	27	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	**1**	**1.7**	4.7	**2.8**	3.3	3.9	4.2	5.6	7.7	6.7	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	**1**	**1.1**	**2.9**	**2.0**	**2.6**	**3.0**	3.5	5.7	7.2	7.0	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	**1**	**1.3**	**1.8**	**1.5**	**2.2**	**2.6**	**3.0**	**3.9**	5.2	4.8	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	**1**	**1.5**	4.2	**1.8**	**2.6**	3.5	4.4	5.2	6.6	5.8	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	**1**	**1.1**	3.4	**2.2**	**3.0**	**2.9**	3.4	4.0	**4.4**	**3.9**	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	**1**	**1**	**1.8**	**2.1**	**2.6**	**2.5**	**2.7**	**3.4**	**3.8**	**3.3**	(1+2ms)-CMA-ES [2]
Artif Bee Colony	**1**	**1.2**	**1.5**	8.9	14	26	315	2547	12654	*55e-6/1e5*	Artif Bee Colony [8]
avg NEWUOA	**1**	**1.2**	4.7	**1.2**	**1.1**	**1.1**	**1.2**	**1.6**	**2.7**	6.9	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	5.7	25	44	14	12	15	25	37	36	422	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	**1**	**1.1**	**2.1**	3.7	10	12	10	10	10	8.3	Adap DE (F-AUC) [10]
DE (Uniform)	**1**	**1.1**	**1.6**	4.4	11	14	11	12	12	8.8	DE (Uniform) [9]
IPOP-aCMA-ES	**1**	**1**	**2.3**	**2.7**	3.7	4.2	3.7	4.5	5.0	**4.2**	IPOP-aCMA-ES [16]
IPOP-CMA-ES	**1**	**1.5**	**2.8**	3.7	4.0	4.6	4.8	5.8	6.8	5.8	IPOP-CMA-ES [22]
CMA+DE-MOS	**1**	**1.1**	**1.2**	4.0	15	17	15	17	18	14	CMA+DE-MOS [18]
NBC-CMA	**1**	**1.3**	**2.2**	5.8	12	12	9.4	10	11	8.7	NBC-CMA [21]
POEMS	**1**	39	269	54	63	113	138	161	313	14624	POEMS [17]
PM-AdapSS-DE	**1**	**1.6**	**1.9**	5.4	12	12	11	11	11	8.7	PM-AdapSS-DE [9, 10]
pPOEMS	**1**	**1.1**	41	43	91	467	735	1010	1223	1506	pPOEMS [17, 20]
Basic RCGA	**1**	**1.1**	**1.9**	10	36	71	210	646	1886	*51e-7/5e4*	Basic RCGA [24]
SPSA	10	47	534	295	205	165	429	785	2270	*48e-7/1e5*	SPSA [13]

Table 39: Running time excess ERT/$\text{ERT}_{\text{best 2009}}$ on f_{15} in **3-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

15 Rastrigin

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
ERT_{best}/D	0.33	0.78	40	457	2095	2761	2810	2863	2929	3014	ERT_{best}/D
(1,2)-CMA-ES	**2.1**	7.9	7.6	31	67	51	50	49	48	47	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	**1.1**	3.3	**2.7**	8.2	12	9.0	8.8	8.7	8.5	8.3	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	**1.6**	3.7	3.6	10	11	8.4	8.3	8.1	7.9	7.7	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	**1.4**	4.7	9.0	39	33	25	25	24	24	23	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	**1.8**	**2.5**	3.9	5.7	7.0	5.3	5.2	5.1	5.0	4.9	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	**1**	**2.1**	**1.2**	**2.9**	8.3	6.3	6.2	6.1	6.0	5.8	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	**1.5**	**2.7**	**2.2**	**2.0**	**2.6**	**2.0**	**1.9**	**1.9**	**1.9**	**1.8**	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	**1.1**	3.2	4.2	3.9	22	17	17	16	16	16	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	**1.8**	3.2	**2.5**	3.8	11	8.3	8.2	8.1	7.9	7.7	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	**1.4**	**2.5**	**2.1**	7.0	7.2	5.5	5.4	5.3	5.1	5.0	(1+2ms)-CMA-ES [2]
Artif Bee Colony	**1.1**	**1.8**	3.6	34	42	88	250	496	*29e-3/1e5*	.	Artif Bee Colony [8]
avg NEWUOA	**2.0**	3.4	3.2	3.7	3.1	**2.3**	**2.3**	**2.2**	**2.2**	**2.1**	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	18	23	12	36	325	519	*99e-2/1e5*	.	.	.	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	**1.3**	**1.9**	**1.8**	**1.4**	**0.41**	**0.37**	**0.38**	**0.40**	**0.40**	**0.43**	Adap DE (F-AUC) [10]
DE (Uniform)	**1**	3.9	**2.3**	**1.6**	3.9	3.0	**3.0**	**3.0**	**2.9**	**2.9**	DE (Uniform) [9]
IPOP-aCMA-ES	**2.5**	4.2	**0.98**	**1.6**	**1.0**	**0.85**	**0.85**	**0.85**	**0.85**	**0.85**	IPOP-aCMA-ES [16]
IPOP-CMA-ES	**1.3**	**2.9**	**2.4**	**1.4**	**1.2**	**0.93**	**0.93**	**0.93**	**0.92**	**0.93**	IPOP-CMA-ES [22]
CMA+DE-MOS	**1.3**	**1.5**	4.9	3.8	**1.5**	**1.6**	**1.6**	**1.6**	**1.6**	**1.6**	CMA+DE-MOS [18]
NBC-CMA	**1.2**	**1.3**	3.2	3.1	3.1	**2.4**	**2.3**	**2.3**	**2.3**	**2.2**	NBC-CMA [21]
POEMS	**1**	217	15	26	85	65	65	64	63	62	POEMS [17]
PM-AdapSS-DE	**1.4**	**2.6**	**2.3**	**1.5**	3.9	3.0	**3.0**	**3.0**	**2.9**	**2.9**	PM-AdapSS-DE [9, 10]
pPOEMS	**1.1**	20	17	46	23	21	23	26	28	32	pPOEMS [17, 20]
Basic RCGA	**1.3**	**2.0**	5.3	24	9.3	7.5	9.4	12	17	39	Basic RCGA [24]
SPSA	282	9719	473	3249	*21e-1/1e5*	.	.	.	.	.	SPSA [13]

Table 40: Running time excess ERT/$\text{ERT}_{\text{best 2009}}$ on f_{16} in **3-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

16 Weierstrass

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
ERT_{best}/D	0.33	0.40	14	106	194	263	621	720	1068	1120	ERT_{best}/D
(1,2)-CMA-ES	**1**	**1.5**	19	37	96	160	68	92	*25e-2/1e4*	.	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	**1**	**1**	**2.4**	12	21	40	26	27	23	42	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	**1**	**1.7**	**2.5**	11	19	25	17	22	16	64	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	**1**	**1.4**	27	33	97	129	115	*17e-2/1e4*	.	.	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	**1**	**1.5**	3.3	13	15	19	10	9.2	8.7	61	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	**1**	**1.3**	5.4	5.3	8.1	8.6	5.6	5.4	5.0	5.0	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	**1**	**1.2**	**1.9**	4.5	5.3	6.5	7.3	10	6.9	6.9	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	**1**	**1.8**	6.2	8.1	12	18	14	19	16	22	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	**1**	**1.4**	3.1	3.7	10	20	28	30	27	66	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	**1**	**1.2**	**1.9**	3.4	4.7	13	12	34	41	60	(1+2ms)-CMA-ES [2]
Artif Bee Colony	**1**	**1.8**	**1.2**	**3.1**	19	142	2272	*45e-4/1e5*	.	.	Artif Bee Colony [8]
avg NEWUOA	**1**	**1.3**	3.7	6.1	23	59	73	*19e-3/7e3*	.	.	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	**1.2**	15	14	91	445	5699	*80e-3/1e5*	.	.	.	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	**1**	**1.3**	**2.5**	4.4	6.7	5.8	**2.7**	12	8.5	8.2	Adap DE (F-AUC) [10]
DE (Uniform)	**1**	**1.2**	**2.2**	4.5	7.3	7.5	3.4	3.1	**2.2**	**2.2**	DE (Uniform) [9]
IPOP-aCMA-ES	**1**	**1.2**	**1.5**	**3.2**	**2.7**	**3.1**	**1.5**	**1.3**	**0.93**	**0.93**	IPOP-aCMA-ES [16]
IPOP-CMA-ES	**1**	**1.7**	**2.2**	**3.2**	**3.8**	**3.3**	**1.4**	**1.3**	**0.88**	**1.1**	IPOP-CMA-ES [22]
CMA+DE-MOS	**1**	**1.2**	**1.5**	5.3	**4.4**	**3.8**	**1.9**	**1.8**	**1.3**	**1.4**	CMA+DE-MOS [18]
NBC-CMA	**1**	**1.5**	**1.5**	7.5	7.1	8.6	3.8	3.4	**2.4**	**2.4**	NBC-CMA [21]
POEMS	**1**	20	18	28	523	521	225	195	133	128	POEMS [17]
PM-AdapSS-DE	**1**	**1.4**	**1.6**	6.4	11	11	17	15	10	10	PM-AdapSS-DE [9, 10]
pPOEMS	**1**	**1.4**	18	15	85	112	105	139	103	119	pPOEMS [17, 20]
Basic RCGA	**1**	**1**	**1.6**	17	45	117	125	135	117	199	Basic RCGA [24]
SPSA	**2.7**	107	106	312	1571	*28e-2/1e5*	.	.	.	.	SPSA [13]

Table 41: Running time excess ERT/ERT$_{\text{best 2009}}$ on f_{17} in **3-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

17 Schaffer F7, condition 10

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
ERT$_{\text{best}}$/D	0.33	0.33	1.2	26	94	164	378	602	782	1156	ERT$_{\text{best}}$/D
(1,2)-CMA-ES	**1**	**1.7**	6.4	11	25	138	*14e-3/1e4*	.	.	.	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	**1**	**1.3**	4.0	5.1	3.9	4.3	11	54	187	*26e-5/1e4*	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	**1**	**1.5**	3.8	**1.3**	5.1	7.5	22	119	184	124	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	**1**	388	113	30	50	859	*44e-3/1e4*	.	.	.	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	**1**	**1.3**	19	7.4	8.4	16	19	28	91	*12e-5/1e4*	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	**1**	**1.6**	4.1	4.5	3.3	5.9	4.2	15	61	129	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	**1**	**1.7**	13	3.6	3.8	3.8	6.5	17	87	*58e-6/1e4*	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	**1**	**1.1**	3.9	4.9	6.9	12	18	*54e-5/1e4*	.	.	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	**1**	**1.4**	12	5.2	15	36	88	243	*26e-4/1e4*	.	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	**1**	**1.2**	10	6.3	6.3	13	17	55	92	125	(1+2ms)-CMA-ES [2]
Artif Bee Colony	**1**	**1.5**	3.2	6.6	11	42	469	2342	1803	*11e-4/1e5*	Artif Bee Colony [8]
avg NEWUOA	**1**	**1.9**	3.3	8.0	13	153	*32e-3/5e3*	.	.	.	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	6.9	19	16	17	12	243	739	2328	1793	*61e-4/1e5*	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	**1**	**1.3**	4.3	**3.3**	**2.7**	**2.6**	**1.6**	**1.4**	**1.3**	**1.2**	Adap DE (F-AUC) [10]
DE (Uniform)	**1**	**1.3**	**2.2**	3.6	**2.8**	**2.7**	**1.7**	**1.4**	**1.4**	**1.3**	DE (Uniform) [9]
IPOP-aCMA-ES	**1.1**	**2.3**	4.5	6.6	**2.8**	**2.1**	**1.6**	**1.2**	**1.2**	**0.95**	IPOP-aCMA-ES [16]
IPOP-CMA-ES	**1**	3.5	20	**2.2**	**1.1**	**1.8**	**1.2**	**1.1**	**1.1**	**1.0**	IPOP-CMA-ES [22]
CMA+DE-MOS	**1**	**1.3**	**2.4**	5.9	6.8	6.2	5.2	4.3	3.7	3.4	CMA+DE-MOS [18]
NBC-CMA	**1**	**1.4**	**2.6**	4.0	**2.1**	**1.7**	**0.93**	**0.72**	**1.4**	**1.2**	NBC-CMA [21]
POEMS	**1**	164	184	22	26	28	18	15	15	30	POEMS [17]
PM-AdapSS-DE	**1**	**1.5**	**1.9**	3.7	**2.5**	**2.7**	**1.7**	**1.3**	**1.3**	**1.2**	PM-AdapSS-DE [9, 10]
pPOEMS	**1.1**	**1.2**	16	19	129	185	125	108	106	105	pPOEMS [17, 20]
Basic RCGA	**1**	**1.3**	3.1	25	72	81	51	111	155	*63e-6/5e4*	Basic RCGA [24]
SPSA	57	21735	32080	4518	1302	2511	*11e-1/1e5*	.	.	.	SPSA [13]

Table 42: Running time excess ERT/$\mathrm{ERT}_{\text{best 2009}}$ on f_{18} in **3-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

18 Schaffer F7, condition 1000

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
$\mathrm{ERT}_{\text{best}}$/D	0.33	0.40	13	48	430	1028	1174	1314	1579	1842	$\mathrm{ERT}_{\text{best}}$/D
(1,2)-CMA-ES	**1.2**	5.9	9.0	29	23	137	*69e-3/1e4*	.	.	.	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	**1**	3.6	**1.3**	10	14	26	*42e-3/1e4*	.	.	.	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	**1**	5.4	**1.4**	4.2	6.1	20	*11e-3/1e4*	.	.	.	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	**1**	5.8	15	46	103	*24e-2/1e4*	.	.	.	.	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	**1.1**	4.1	5.4	7.2	5.5	16	120	*12e-3/1e4*	.	.	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	**1.1**	48	4.6	5.0	3.1	6.2	18	*24e-4/1e4*	.	.	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	**1**	4.2	4.0	4.7	5.8	8.7	17	107	*15e-4/1e4*	.	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	**1.2**	4.6	5.2	12	8.8	19	125	*15e-3/1e4*	.	.	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	**1**	3.6	6.0	21	11	35	*42e-3/1e4*	.	.	.	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	**1**	61	5.8	11	9.5	26	128	*24e-3/1e4*	.	.	(1+2ms)-CMA-ES [2]
Artif Bee Colony	**1**	3.1	3.4	15	70	315	*23e-3/1e5*	.	.	.	Artif Bee Colony [8]
avg NEWUOA	**1.3**	4.8	11	30	15	89	*76e-3/6e3*	.	.	.	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	12	38	13	62	284	*19e-2/1e5*	.	.	.	.	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	**1.1**	**2.6**	**2.9**	3.7	**0.86**	**0.57**	**0.67**	**0.76**	**0.78**	**0.86**	Adap DE (F-AUC) [10]
DE (Uniform)	**1.5**	**2.8**	3.5	3.6	**0.86**	**0.57**	**0.68**	**0.77**	**0.78**	**0.86**	DE (Uniform) [9]
IPOP-aCMA-ES	**1**	7.4	**1.3**	**1.3**	**0.61**	**0.91**	**0.90**	**0.86**	**0.92**	**0.94**	IPOP-aCMA-ES [16]
IPOP-CMA-ES	**1.3**	6.4	**1.4**	**1.8**	**1.2**	**1.0**	**1.2**	**1.3**	**1.4**	**1.3**	IPOP-CMA-ES [22]
CMA+DE-MOS	**1.1**	**1.8**	**2.9**	7.8	**2.1**	**1.7**	**2.0**	**1.9**	**1.8**	**2.0**	CMA+DE-MOS [18]
NBC-CMA	**1.3**	3.4	**2.3**	4.8	19	8.1	7.1	6.6	5.8	5.4	NBC-CMA [21]
POEMS	43	260	23	27	8.9	50	110	107	158	226	POEMS [17]
PM-AdapSS-DE	**1.5**	3.6	**2.1**	**3.6**	**0.86**	**0.55**	**0.66**	**0.76**	**0.77**	**0.85**	PM-AdapSS-DE [9, 10]
pPOEMS	**1.1**	54	28	82	55	42	53	67	68	83	pPOEMS [17, 20]
Basic RCGA	**1**	**1.6**	24	86	61	327	*33e-3/5e4*	.	.	.	Basic RCGA [24]
SPSA	43	1240	3787	3149	1547	*20e-1/1e5*	.	.	.	.	SPSA [13]

Table 43: Running time excess ERT/$\text{ERT}_{\text{best 2009}}$ on f_{19} in **3-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

19 Griewank-Rosenbrock F8F2

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
ERT_{best}/D	0.33	0.33	0.33	0.33	36	2255	2456	2460	2466	2480	ERT_{best}/D
(1,2)-CMA-ES	**1**	**1**	**4.8**	469	177	30	*32e-3/1e4*	.	.	.	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	**1**	**1**	6.7	239	132	20	*39e-3/1e4*	.	.	.	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	**1**	**1**	8.5	556	87	21	29	29	29	29	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	**1**	**1**	31	550	173	31	58	58	58	58	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	**1**	**1**	**5.5**	329	99	6.7	12	12	12	12	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	**1**	**1.1**	10	420	60	10	13	13	13	12	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	**1**	**1**	10	**171**	89	6.7	28	28	27	27	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	**1**	**1**	11	251	123	65	*58e-3/1e4*	.	.	.	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	**1**	**1**	7.4	415	186	20	18	18	18	18	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	**1**	**1.1**	12	364	121	14	28	28	28	28	(1+2ms)-CMA-ES [2]
Artif Bee Colony	**1**	**1.1**	12	391	52	8.0	24	72	295	*14e-5/1e5*	Artif Bee Colony [8]
avg NEWUOA	**1**	**1.5**	13	319	122	39	76	76	76	76	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	6.2	15	47	346	150	49	98	266	265	566	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	**1**	**1.1**	12	218	27	5.0	12	12	12	12	Adap DE (F-AUC) [10]
DE (Uniform)	**1**	**1.1**	7.3	335	32	5.5	13	13	13	13	DE (Uniform) [9]
IPOP-aCMA-ES	**1**	**1**	**6.0**	234	41	4.0	4.6	4.6	4.7	4.7	IPOP-aCMA-ES [16]
IPOP-CMA-ES	**1**	**1.1**	11	**196**	67	4.4	**4.1**	**4.1**	**4.1**	**4.1**	IPOP-CMA-ES [22]
CMA+DE-MOS	**1**	**1.1**	11	**213**	**5.8**	**3.7**	**3.6**	**3.7**	**3.7**	**3.8**	CMA+DE-MOS [18]
NBC-CMA	**1**	**1.2**	8.9	235	29	**3.2**	**4.3**	**4.3**	**4.3**	**4.3**	NBC-CMA [21]
POEMS	**1**	42	611	1680	251	81	168	167	169	169	POEMS [17]
PM-AdapSS-DE	**1**	**1.9**	7.9	237	**25**	**2.3**	12	12	12	14	PM-AdapSS-DE [9, 10]
pPOEMS	**1**	**1.5**	260	1717	259	10	11	13	15	21	pPOEMS [17, 20]
Basic RCGA	**1**	**1.1**	10	273	**16**	8.7	24	51	141	289	Basic RCGA [24]
SPSA	18	71	258	10394	2974	637	*83e-3/1e5*	.	.	.	SPSA [13]

Table 44: Running time excess ERT/$\text{ERT}_{\text{best 2009}}$ on f_{20} in **3-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

20 Schwefel x*sin(x)

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
ERT_{best}/D	1.8	2.6	2.8	128	764	799	827	842	858	925	ERT_{best}/D
(1,2)-CMA-ES	4.5	4.2	4.9	4.1	16	15	17	17	16	15	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	**2.4**	**2.8**	3.2	8.1	41	39	38	37	36	34	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	**2.6**	3.2	3.9	7.9	91	87	84	83	81	75	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	4.3	7.9	7.7	11	32	32	31	31	30	28	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	**1.8**	**2.0**	**2.8**	4.1	11	11	10	10	10	9.2	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	**1.3**	**1.3**	**2.0**	7.8	18	17	16	16	16	15	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	**1.2**	**1.6**	**1.7**	4.7	54	52	50	49	48	45	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	**0.95**	**1.4**	**1.9**	6.0	21	20	19	19	19	17	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	**2.1**	**2.1**	**2.4**	**3.0**	10	10	9.5	9.3	9.1	8.5	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	**1.3**	**1.4**	**1.8**	**2.0**	9.2	8.8	8.5	8.4	8.3	**7.7**	(1+2ms)-CMA-ES [2]
Artif Bee Colony	**2.6**	5.0	5.6	**1.1**	**1.3**	**1.8**	**3.7**	6.0	6.9	9.3	Artif Bee Colony [8]
avg NEWUOA	**1.5**	**1.3**	**1.3**	**2.3**	10	9.5	9.2	9.0	8.9	8.2	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	10	12	13	158	*45e-2/1e5*	.	.	.	.	.	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	**1.6**	**2.9**	4.5	3.7	34	33	32	31	31	28	Adap DE (F-AUC) [10]
DE (Uniform)	**2.9**	3.4	4.6	**2.8**	34	32	32	31	31	28	DE (Uniform) [9]
IPOP-aCMA-ES	**2.3**	**1.9**	**2.0**	5.1	5.8	5.9	5.9	**5.9**	**5.9**	**5.6**	IPOP-aCMA-ES [16]
IPOP-CMA-ES	**2.1**	**2.8**	**2.9**	4.5	**5.6**	**5.7**	**5.6**	**5.7**	**5.7**	**5.4**	IPOP-CMA-ES [22]
CMA+DE-MOS	**3.0**	3.9	4.5	4.3	**3.5**	**4.0**	**4.8**	**4.9**	**5.1**	7.8	CMA+DE-MOS [18]
NBC-CMA	**1.9**	4.0	4.9	3.8	13	12	12	12	12	11	NBC-CMA [21]
POEMS	110	83	80	8.2	146	141	138	137	135	128	POEMS [17]
PM-AdapSS-DE	**1.9**	**2.5**	**2.8**	**2.8**	21	20	20	19	19	18	PM-AdapSS-DE [9, 10]
pPOEMS	63	60	65	20	17	27	36	44	52	64	pPOEMS [17, 20]
Basic RCGA	**2.2**	3.2	4.6	64	217	916	887	*41e-2/5e4*	.	.	Basic RCGA [24]
SPSA	34	39	51	5071	*15e-1/1e5*	.	.	.	.	.	SPSA [13]

Table 45: Running time excess ERT/ERT$_{\text{best 2009}}$ on f_{21} in **3-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

21 Gallagher 101 peaks

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
ERT$_{\text{best}}$/D	0.33	0.33	2.0	61	142	146	153	155	156	161	ERT$_{\text{best}}$/D
(1,2)-CMA-ES	**1**	**1**	6.8	11	25	28	27	27	27	26	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	**1**	**1**	**1.6**	7.7	7.7	11	11	11	11	11	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	**1**	**1**	**1.8**	8.1	12	13	18	17	17	17	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	**1**	**1**	4.1	21	40	42	40	40	40	39	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	**1**	**1**	**1.4**	7.4	13	13	12	12	12	12	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	**1**	**1**	**1.1**	5.4	21	26	27	27	27	26	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	**1**	**1**	**2.6**	5.1	7.4	7.3	7.0	6.9	6.9	6.8	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	**1**	**1**	**2.4**	8.0	11	11	11	11	11	10	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	**1**	**1**	**2.5**	5.3	10	10	9.4	9.2	9.2	9.0	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	**1**	**1**	**1.7**	7.4	8.9	8.7	8.4	8.3	8.2	8.1	(1+2ms)-CMA-ES [2]
Artif Bee Colony	**1**	**1**	**2.4**	**2.5**	3.7	5.9	10	26	60	145	Artif Bee Colony [8]
avg NEWUOA	**1**	**1**	4.0	**2.5**	**2.1**	**2.0**	**2.0**	**2.0**	**2.0**	**2.0**	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	**1**	19	10	35	220	305	293	577	573	559	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	**1**	**1**	**2.0**	**2.1**	**1.6**	**2.0**	**2.4**	**2.7**	**2.9**	**3.1**	Adap DE (F-AUC) [10]
DE (Uniform)	**1**	**1**	**1.3**	**1.9**	**1.9**	**2.3**	**2.6**	**2.8**	**3.0**	**3.3**	DE (Uniform) [9]
IPOP-aCMA-ES	**1**	**1**	**1.8**	6.6	10	10	10	10	11	11	IPOP-aCMA-ES [16]
IPOP-CMA-ES	**1**	**1**	**1.5**	11	10	11	11	11	11	11	IPOP-CMA-ES [22]
CMA+DE-MOS	**1**	**1**	**1.7**	13	22	106	488	746	744	860	CMA+DE-MOS [18]
NBC-CMA	**1**	**1**	**1.3**	5.1	31	55	52	52	51	50	NBC-CMA [21]
POEMS	**1**	**1**	90	1001	800	777	745	739	735	722	POEMS [17]
PM-AdapSS-DE	**1**	**1**	**1.1**	**1.7**	52	51	49	48	48	47	PM-AdapSS-DE [9, 10]
pPOEMS	**1**	**1**	31	12	11	24	39	57	92	145	pPOEMS [17, 20]
Basic RCGA	**1**	**1**	**1.8**	21	59	162	164	216	269	293	Basic RCGA [24]
SPSA	**1**	30	30	439	1223	1188	1139	1134	1155	2915	SPSA [13]

Table 46: Running time excess ERT/ERT$_{\text{best 2009}}$ on f_{22} in **3-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

22 Gallagher 21 peaks

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
ERT$_{\text{best}}$/D	0.33	0.33	6.0	57	118	121	128	132	134	138	ERT$_{\text{best}}$/D
(1,2)-CMA-ES	**1**	**1**	4.0	17	28	35	34	33	33	32	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	**1**	**1**	15	11	22	25	25	25	25	24	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	**1**	**1**	7.1	7.6	20	31	30	35	34	33	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	**1**	**1**	18	16	26	26	27	27	27	27	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	**1**	**1**	4.0	7.8	7.8	7.9	7.6	7.5	7.4	7.3	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	**1**	**1**	3.6	6.8	7.3	7.4	7.2	7.2	7.1	7.1	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	**1**	**1**	**2.8**	10	15	16	15	15	15	14	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	**1**	**1**	9.0	7.0	10	10	10	9.4	9.3	9.1	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	**1**	**1**	6.4	8.7	7.2	**7.2**	**6.9**	**6.8**	**6.7**	**6.6**	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	**1**	**1**	3.1	**2.7**	**3.4**	**3.5**	**3.3**	**3.3**	**3.3**	**3.3**	(1+2ms)-CMA-ES [2]
Artif Bee Colony	**1**	**1**	**2.5**	**1.7**	**4.3**	29	105	241	329	4862	Artif Bee Colony [8]
avg NEWUOA	**1**	**1**	**2.8**	**2.0**	**2.9**	**2.9**	**2.8**	**2.9**	**2.9**	**3.1**	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	**1**	16	3.6	43	237	523	798	1172	1152	1117	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	**1**	**1**	**2.1**	**2.2**	132	130	123	120	118	115	Adap DE (F-AUC) [10]
DE (Uniform)	**1**	**1**	**1.3**	**1.5**	132	130	123	120	118	115	DE (Uniform) [9]
IPOP-aCMA-ES	**1**	**1**	6.6	7.1	27	83	228	224	222	217	IPOP-aCMA-ES [16]
IPOP-CMA-ES	**1**	**1**	**1.2**	5.0	21	90	247	290	286	281	IPOP-CMA-ES [22]
CMA+DE-MOS	**1**	**1**	**1.5**	16	22	28	31	42	44	193	CMA+DE-MOS [18]
NBC-CMA	**1**	**1**	**1.4**	109	174	225	213	208	204	198	NBC-CMA [21]
POEMS	**1**	**1**	2130	623	989	974	921	901	889	868	POEMS [17]
PM-AdapSS-DE	**1**	**1**	**1.3**	127	213	209	198	193	190	184	PM-AdapSS-DE [9, 10]
pPOEMS	**1**	**1**	29	12	211	227	234	266	298	361	pPOEMS [17, 20]
Basic RCGA	**1**	**1**	**1.3**	32	111	389	518	601	1218	5387	Basic RCGA [24]
SPSA	**1**	28	31	320	5903	12219	*40e-2/1e5*	.	.	.	SPSA [13]

Table 47: Running time excess ERT/ERT$_{\text{best 2009}}$ on f_{23} in **3-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

23 Katsuuras

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
ERT$_{\text{best}}$/D	0.33	0.33	0.87	136	302	405	738	751	764	798	ERT$_{\text{best}}$/D
(1,2)-CMA-ES	**1**	**1**	7.2	37	237	177	197	194	190	*68e-2/1e4*	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	**1**	**1**	6.5	12	48	104	57	89	87	*22e-2/1e4*	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	**1**	**1**	5.3	18	69	81	45	64	63	61	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	**1**	**1**	10	54	231	180	199	*66e-2/1e4*	.	.	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	**1**	**1**	**2.5**	7.3	20	16	10	10	10	11	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	**1**	**1**	**3.0**	6.2	19	21	14	14	14	13	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	**1**	**1**	6.1	8.2	30	27	15	14	14	14	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	**1**	**1**	9.5	16	40	41	34	43	43	55	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	**1**	**1**	5.6	3.4	13	19	13	15	20	29	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	**1**	**1**	4.9	3.6	10	21	16	25	24	23	(1+2ms)-CMA-ES [2]
Artif Bee Colony	**1**	**1**	4.2	10	*24e-2/1e5*	.	.	.	.	.	Artif Bee Colony [8]
avg NEWUOA	**1**	**1**	11	**2.5**	22	85	147	*46e-3/7e3*	.	.	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	**1**	7.1	16	11	*29e-2/1e5*	.	.	.	.	.	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	**1**	**1**	3.1	3.1	**5.1**	**6.6**	**5.1**	**6.4**	**7.8**	**10**	Adap DE (F-AUC) [10]
DE (Uniform)	**1**	**1**	4.0	**2.4**	**5.3**	**7.2**	5.5	6.9	8.4	11	DE (Uniform) [9]
IPOP-aCMA-ES	**1**	**1**	7.2	5.3	10	**7.7**	**4.3**	**5.4**	**5.4**	**5.4**	IPOP-aCMA-ES [16]
IPOP-CMA-ES	**1**	**1**	4.9	5.2	80	60	33	32	32	31	IPOP-CMA-ES [22]
CMA+DE-MOS	**1**	**1**	3.9	7.5	10	8.6	**5.2**	**5.2**	**5.3**	**5.4**	CMA+DE-MOS [18]
NBC-CMA	**1**	**1**	**2.7**	15	353	263	145	142	140	134	NBC-CMA [21]
POEMS	**1**	**1**	20	21	106	141	83	85	86	88	POEMS [17]
PM-AdapSS-DE	**1**	**1**	4.1	**2.5**	**5.7**	26	16	17	19	20	PM-AdapSS-DE [9, 10]
pPOEMS	**1**	**1**	14	64	264	276	189	227	255	328	pPOEMS [17, 20]
Basic RCGA	**1**	**1**	5.4	16	271	837	*15e-2/5e4*	.	.	.	Basic RCGA [24]
SPSA	**1**	26	113	946	*99e-2/1e5*	.	.	.	.	.	SPSA [13]

Table 48: Running time excess ERT/$\text{ERT}_{\text{best 2009}}$ on f_{24} in **3-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

24 Lunacek bi-Rastrigin

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
ERT_{best}/D	0.33	0.33	32	3464	34218	1.19e5	1.19e5	1.19e5	1.19e5	1.19e5	ERT_{best}/D
(1,2)-CMA-ES	**1**	**1**	6.9	43	*18e-1/1e4*	.	.	.	.	.	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	**1**	**1**	**2.0**	20	*14e-1/1e4*	.	.	.	.	.	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	**1**	**1**	3.3	7.5	*19e-1/1e4*	.	.	.	.	.	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	**1**	**1**	12	*31e-1/1e4*	.	.	.	.	.	.	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	**1**	**1**	3.2	13	*14e-1/1e4*	.	.	.	.	.	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	**1**	**1**	**1.5**	**2.5**	*85e-2/1e4*	.	.	.	.	.	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	**1**	**1.1**	**1.4**	4.1	**2.1**	**1.2**	**1.2**	**1.2**	**1.2**	**1.2**	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	**1**	**1**	5.3	3.9	*86e-2/1e4*	.	.	.	.	.	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	**1**	**1.1**	6.6	**3.4**	*97e-2/1e4*	.	.	.	.	.	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	**1**	**1**	**2.0**	4.7	*10e-1/1e4*	.	.	.	.	.	(1+2ms)-CMA-ES [2]
Artif Bee Colony	**1**	**1.4**	4.8	8.4	*54e-2/1e5*	.	.	.	.	.	Artif Bee Colony [8]
avg NEWUOA	**1**	**2.6**	3.7	**1.2**	**2.4**	*64e-2/6e3*	.	.	.	.	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	27	31	4.0	14	*40e-2/1e5*	.	.	.	.	.	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	**1**	**1**	3.0	80	8.1	3.4	3.4	3.4	3.4	3.4	Adap DE (F-AUC) [10]
DE (Uniform)	**1**	**1.1**	3.7	58	5.9	**1.7**	**1.7**	**1.7**	**1.7**	**1.7**	DE (Uniform) [9]
IPOP-aCMA-ES	**1**	**1**	**2.7**	146	64	39	39	39	39	39	IPOP-aCMA-ES [16]
IPOP-CMA-ES	**1**	**1.1**	**1.9**	272	*30e-1/3e5*	.	.	.	.	.	IPOP-CMA-ES [22]
CMA+DE-MOS	**1**	**1.2**	6.4	7.9	**3.5**	**1.5**	**1.9**	**1.9**	**1.9**	**1.9**	CMA+DE-MOS [18]
NBC-CMA	**1**	**1.1**	**2.8**	24	43	*51e-2/1e5*	.	.	.	.	NBC-CMA [21]
POEMS	**1**	44	17	564	*31e-1/3e5*	.	.	.	.	.	POEMS [17]
PM-AdapSS-DE	**1**	**1.7**	4.0	58	12	3.5	5.7	5.7	5.7	5.7	PM-AdapSS-DE [9, 10]
pPOEMS	**1**	**1.3**	19	65	12	4.3	4.4	4.5	4.5	4.7	pPOEMS [17, 20]
Basic RCGA	**1**	**1.3**	5.0	45	21	6.2	*17e-1/5e4*	.	.	.	Basic RCGA [24]
SPSA	59	528	14979	*14e+0/1e5*	.	.	.	.	.	.	SPSA [13]

Table 49: Running time excess ERT/ERT$_{\text{best 2009}}$ on f_1 in **5-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

1 Sphere

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
ERT$_{\text{best}}$/D	0.20	0.20	2.2	2.4	2.4	2.4	2.4	2.4	2.4	2.4	ERT$_{\text{best}}$/D
(1,2)-CMA-ES	**1**	3.1	7.4	15	27	37	47	54	63	80	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	**1**	**1**	3.2	10	15	21	28	35	40	53	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	**1**	**1.3**	**2.1**	7.2	13	18	24	30	35	45	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	**1**	**1.3**	4.5	12	22	29	38	48	55	71	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	**1**	**1.1**	**2.5**	6.9	11	16	21	25	30	40	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	**1**	**1.1**	**2.2**	6.2	10	15	19	23	27	37	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	**1**	**1**	**2.0**	**5.0**	**8.3**	**12**	**15**	**18**	**22**	**30**	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	**1**	**1.9**	**2.5**	6.5	10	15	18	22	26	34	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	**1**	**1.1**	**2.1**	5.6	10	13	17	21	24	32	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	**1**	**1**	**1.5**	**4.9**	**8.0**	**12**	**15**	**18**	**21**	**28**	(1+2ms)-CMA-ES [2]
Artif Bee Colony	**1**	**1.4**	12	32	62	89	122	156	191	255	Artif Bee Colony [8]
avg NEWUOA	**1**	3.3	**1.5**	**1.3**	**1.3**	**1.3**	**1.3**	**1.3**	**1.3**	**1.3**	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	**2.3**	27	7.2	16	24	34	43	55	67	87	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	**1**	**1.3**	5.9	37	67	104	132	166	203	266	Adap DE (F-AUC) [10]
DE (Uniform)	**1**	**1.3**	8.6	42	80	117	155	194	236	313	DE (Uniform) [9]
IPOP-aCMA-ES	**1**	**1.3**	3.2	8.9	15	22	27	33	39	51	IPOP-aCMA-ES [16]
IPOP-CMA-ES	**1**	**1.1**	**2.5**	8.0	14	20	27	32	39	51	IPOP-CMA-ES [22]
CMA+DE-MOS	**1**	**1.1**	6.5	33	66	90	121	142	169	217	CMA+DE-MOS [18]
NBC-CMA	**1**	**1.3**	5.6	26	42	53	65	74	85	108	NBC-CMA [21]
POEMS	**1**	263	102	136	329	766	1195	1592	2001	2796	POEMS [17]
PM-AdapSS-DE	**1**	**2.1**	4.8	39	74	111	145	182	223	292	PM-AdapSS-DE [9, 10]
pPOEMS	**1**	**1.2**	97	129	614	2849	5775	8274	12299	18337	pPOEMS [17, 20]
Basic RCGA	**1**	**1.1**	8.7	72	155	329	561	831	1141	1741	Basic RCGA [24]
SPSA	**1**	43	11	15	19	22	27	31	36	44	SPSA [13]

Table 50: Running time excess ERT/ERT$_{\text{best 2009}}$ on f_2 in **5-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

2 Ellipsoid separable

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
ERT$_{\text{best}}$/D	10	15	17	17	18	18	18	18	18	19	ERT$_{\text{best}}$/D
(1,2)-CMA-ES	46	45	57	61	64	65	66	67	68	69	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	28	30	37	40	42	43	44	44	45	46	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	30	27	30	34	35	36	36	36	37	37	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	35	59	66	74	81	83	85	86	87	89	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	13	14	20	22	24	24	25	25	26	27	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	11	12	16	19	22	22	23	23	24	24	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	8.6	12	14	15	16	16	17	17	18	18	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	12	15	18	21	22	22	23	23	23	24	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	**6.0**	**6.9**	11	**13**	**13**	**14**	**14**	**14**	**15**	**15**	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	**6.6**	**7.7**	**10**	**11**	**12**	**12**	**13**	**13**	**13**	**14**	(1+2ms)-CMA-ES [2]
Artif Bee Colony	10	8.9	11	18	26	30	38	44	50	62	Artif Bee Colony [8]
avg NEWUOA	**1.2**	**2.0**	**6.4**	21	41	56	75	92	108	145	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	48	53	68	69	69	70	72	72	73	75	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	13	14	18	22	26	30	35	38	42	50	Adap DE (F-AUC) [10]
DE (Uniform)	14	16	20	24	30	35	40	45	50	58	DE (Uniform) [9]
IPOP-aCMA-ES	7.5	8.5	**10**	**12**	**14**	**14**	**15**	**16**	**16**	**18**	IPOP-aCMA-ES [16]
IPOP-CMA-ES	9.4	10	14	16	18	18	19	20	21	22	IPOP-CMA-ES [22]
CMA+DE-MOS	16	19	23	29	35	40	46	51	55	64	CMA+DE-MOS [18]
NBC-CMA	16	18	23	27	30	31	33	34	35	37	NBC-CMA [21]
POEMS	119	145	200	295	341	371	438	494	550	636	POEMS [17]
PM-AdapSS-DE	15	16	19	24	28	33	38	42	47	55	PM-AdapSS-DE [9, 10]
pPOEMS	139	842	1208	1316	1735	2219	2549	2927	3091	3928	pPOEMS [17, 20]
Basic RCGA	34	46	78	125	169	207	252	309	347	1069	Basic RCGA [24]
SPSA	5535	43870	*46e+1/1e5*	.	.	.	.	.	.	.	SPSA [13]

Table 51: Running time excess ERT/ERT$_{\text{best 2009}}$ on f_3 in **5-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

3 Rastrigin separable

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
ERT$_{\text{best}}$/D	0.20	2.9	143	324	327	328	329	330	330	331	ERT$_{\text{best}}$/D
(1,2)-CMA-ES	**2.7**	24	39	*80e-1/1e4*	.	.	.	.	.	.	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	**1.2**	**2.6**	3.5	147	454	453	452	451	451	450	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	**1**	**1.6**	6.2	441	*30e-1/1e4*	.	.	.	.	.	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	**2.2**	15	28	225	*60e-1/1e4*	.	.	.	.	.	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	**1**	**1.4**	4.3	434	*20e-1/1e4*	.	.	.	.	.	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	**1.5**	**1.5**	4.5	79	443	442	441	440	440	439	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	**1.3**	**1.6**	**2.8**	98	*20e-1/1e4*	.	.	.	.	.	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	**1.2**	**1.1**	5.9	*30e-1/1e4*	.	.	.	.	.	.	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	**1.7**	**1.6**	7.2	*30e-1/1e4*	.	.	.	.	.	.	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	**1.9**	**1.8**	3.4	91	*20e-1/1e4*	.	.	.	.	.	(1+2ms)-CMA-ES [2]
Artif Bee Colony	**1.3**	**2.7**	**1.0**	**1.5**	**1.8**	**2.4**	**2.7**	**3.2**	**3.6**	**4.4**	Artif Bee Colony [8]
avg NEWUOA	3.3	4.8	**3.0**	130	*40e-1/6e3*	.	.	.	.	.	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	18	7.6	40	2261	4484	4473	4463	*20e-1/1e5*	.	.	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	**1.2**	**2.7**	3.4	12	59	59	60	60	60	60	Adap DE (F-AUC) [10]
DE (Uniform)	**1**	**1.6**	3.5	12	125	125	125	125	125	126	DE (Uniform) [9]
IPOP-aCMA-ES	**1.4**	**2.4**	**1.1**	20	1359	1356	1353	1351	1350	1348	IPOP-aCMA-ES [16]
IPOP-CMA-ES	**2.3**	**1.7**	**2.2**	70	3130	3121	3113	3108	3106	3099	IPOP-CMA-ES [22]
CMA+DE-MOS	**1.2**	3.3	**1.5**	**1.6**	**2.4**	**2.9**	**3.2**	**3.4**	**3.8**	**4.4**	CMA+DE-MOS [18]
NBC-CMA	**1.5**	**2.1**	**1.9**	30	155	154	154	154	154	154	NBC-CMA [21]
POEMS	168	77	4.0	**11**	**36**	**38**	**42**	**45**	**48**	**54**	POEMS [17]
PM-AdapSS-DE	**1.5**	**2.1**	4.9	33	166	217	362	470	621	621	PM-AdapSS-DE [9, 10]
pPOEMS	**1.3**	66	4.8	30	64	92	116	140	158	203	pPOEMS [17, 20]
Basic RCGA	**1.1**	4.0	3.4	37	89	95	114	116	118	120	Basic RCGA [24]
SPSA	54	8613	*21e+0/1e5*	.	.	.	.	.	.	.	SPSA [13]

Table 52: Running time excess ERT/ERT$_{\text{best 2009}}$ on f_4 in **5-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

4 Skew Rastrigin-Bueche separ

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
ERT$_{\text{best}}$/D	0.20	3.8	162	327	338	352	363	370	377	381	ERT$_{\text{best}}$/D
(1,2)-CMA-ES	3.5	13	75	*80e-1/1e4*	.	.	.	.	.	.	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	**1.3**	3.0	11	*40e-1/1e4*	.	.	.	.	.	.	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	**1.1**	3.4	8.8	445	*30e-1/1e4*	.	.	.	.	.	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	6.5	10	48	*98e-1/1e4*	.	.	.	.	.	.	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	**1.7**	**2.0**	10	*40e-1/1e4*	.	.	.	.	.	.	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	**1.8**	**1.9**	4.6	450	*40e-1/1e4*	.	.	.	.	.	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	**1.5**	**1.7**	**2.9**	456	*30e-1/1e4*	.	.	.	.	.	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	3.1	3.0	11	448	433	416	403	395	388	385	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	**2.3**	**1.9**	22	*50e-1/1e4*	.	.	.	.	.	.	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	**1.8**	**2.0**	7.1	444	*40e-1/1e4*	.	.	.	.	.	(1+2ms)-CMA-ES [2]
Artif Bee Colony	**1.5**	5.7	**1.1**	**2.4**	**2.9**	**3.4**	**4.3**	**4.6**	**4.9**	**6.0**	Artif Bee Colony [8]
avg NEWUOA	5.4	10	14	*50e-1/8e3*	.	.	.	.	.	.	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	28	5.2	309	*70e-1/1e5*	.	.	.	.	.	.	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	**1.4**	5.8	5.7	625	*20e-1/1e5*	.	.	.	.	.	Adap DE (F-AUC) [10]
DE (Uniform)	**1.6**	5.2	5.1	626	1941	1864	1803	1771	1739	1723	DE (Uniform) [9]
IPOP-aCMA-ES	**2.1**	**2.5**	**1.8**	*29e-1/2e5*	.	.	.	.	.	.	IPOP-aCMA-ES [16]
IPOP-CMA-ES	**2.7**	**2.6**	**2.0**	*29e-1/2e5*	.	.	.	.	.	.	IPOP-CMA-ES [22]
CMA+DE-MOS	**1.6**	3.1	**1.6**	**3.6**	**5.6**	**5.8**	**6.1**	**6.4**	**6.6**	**7.3**	CMA+DE-MOS [18]
NBC-CMA	**1.7**	4.6	**2.6**	221	1252	1202	1163	1142	1121	1111	NBC-CMA [21]
POEMS	240	60	4.9	43	118	117	**116**	**118**	**119**	**124**	POEMS [17]
PM-AdapSS-DE	3.3	6.9	4.9	4295	*30e-1/1e5*	.	.	.	.	.	PM-AdapSS-DE [9, 10]
pPOEMS	**1.5**	67	6.8	**36**	**79**	**106**	120	141	158	198	pPOEMS [17, 20]
Basic RCGA	**1.9**	6.7	14	*30e-1/5e4*	.	.	.	.	.	.	Basic RCGA [24]
SPSA	67	2112	4238	*36e+0/1e5*	.	.	.	.	.	.	SPSA [13]

Table 53: Running time excess ERT/$\text{ERT}_{\text{best 2009}}$ on f_5 in **5-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

5 Linear slope

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
ERT_{best}/D	0.20	0.29	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	ERT_{best}/D
(1,2)-CMA-ES	**1**	4.9	5.7	7.5	8.1	8.1	8.1	8.1	8.1	8.1	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	**1**	**2.6**	3.1	4.8	4.8	4.9	4.9	4.9	4.9	4.9	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	**1**	**2.0**	**2.6**	3.3	3.5	3.5	3.5	3.5	3.5	3.5	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	**1**	3.1	5.7	8.4	9.1	9.1	9.1	9.1	9.1	9.1	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	**1**	**1.8**	3.2	4.3	4.5	4.5	4.5	4.5	4.5	4.5	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	**1**	**2.7**	3.3	4.5	4.8	4.8	4.8	4.8	4.8	4.8	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	**1**	**1.8**	**2.4**	3.5	3.6	3.6	3.6	3.6	3.6	3.6	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	**1**	**1.5**	**2.9**	3.9	4.0	4.0	4.0	4.0	4.0	4.0	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	**1**	**2.9**	**2.0**	**2.9**	**3.0**	**3.0**	**3.0**	**3.0**	**3.0**	**3.0**	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	**1**	**1.4**	**1.8**	**2.7**	**2.9**	**2.9**	**2.9**	**2.9**	**2.9**	**2.9**	(1+2ms)-CMA-ES [2]
Artif Bee Colony	**1**	**1.4**	32	49	58	59	59	59	59	59	Artif Bee Colony [8]
avg NEWUOA	**1**	4.1	**1.8**	**1.9**	**1.9**	**1.9**	**1.9**	**1.9**	**1.9**	**1.9**	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	**1**	9.0	4.9	6.9	7.2	7.3	7.3	7.3	7.3	7.3	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	**1**	**1.7**	15	23	24	24	24	24	24	24	Adap DE (F-AUC) [10]
DE (Uniform)	**1**	**1.4**	20	34	35	35	35	35	35	35	DE (Uniform) [9]
IPOP-aCMA-ES	**1**	3.7	4.6	6.3	6.8	6.8	6.8	6.8	6.8	6.8	IPOP-aCMA-ES [16]
IPOP-CMA-ES	**1**	4.5	4.6	6.0	6.3	6.3	6.3	6.3	6.3	6.3	IPOP-CMA-ES [22]
CMA+DE-MOS	**1**	**1.8**	20	42	50	50	51	51	51	51	CMA+DE-MOS [18]
NBC-CMA	**1**	**1.8**	33	39	43	43	43	43	43	43	NBC-CMA [21]
POEMS	**1**	430	161	203	222	229	230	231	231	231	POEMS [17]
PM-AdapSS-DE	**1**	**1.5**	24	33	36	36	36	36	36	36	PM-AdapSS-DE [9, 10]
pPOEMS	**1**	**1.3**	153	203	215	217	218	218	218	218	pPOEMS [17, 20]
Basic RCGA	**1**	**2.0**	327	747	1146	1577	2004	2429	2866	3740	Basic RCGA [24]
SPSA	**1**	12	9.3	13	14	14	14	14	14	14	SPSA [13]

Table 54: Running time excess ERT/$\text{ERT}_{\text{best 2009}}$ on f_6 in **5-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

6 Attractive sector

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
ERT_{best}/D	2.3	3.2	23	43	56	81	116	149	208	266	ERT_{best}/D
(1,2)-CMA-ES	**2.6**	13	5.9	5.1	5.0	4.8	4.3	4.2	3.9	4.0	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	**1.5**	6.4	**2.7**	**2.4**	**2.5**	**2.1**	**1.8**	**1.7**	**1.4**	**1.4**	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	**1.5**	4.2	**2.2**	**2.0**	**2.1**	**1.9**	**1.6**	**1.4**	**1.1**	**1.1**	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	4.8	11	6.5	6.6	7.7	7.3	6.8	6.5	5.8	5.9	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	**2.2**	**2.4**	**1.6**	**1.8**	**1.8**	**1.7**	**1.5**	**1.4**	**1.3**	**1.2**	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	**2.2**	4.7	**1.8**	**1.6**	**1.7**	**1.5**	**1.3**	**1.2**	**1.00**	**0.96**	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	**1.9**	**2.8**	**1.1**	**1.1**	**1.2**	**1.1**	**0.91**	**0.83**	**0.70**	**0.69**	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	**2.0**	5.0	**1.8**	**1.9**	**1.9**	**1.8**	**1.5**	**1.4**	**1.1**	**1.1**	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	**1.8**	3.5	**1.8**	**1.5**	**1.9**	**1.7**	**1.4**	**1.3**	**1.1**	**1.4**	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	**1.2**	**2.3**	**1.1**	**1.2**	**1.6**	**1.4**	**1.4**	**1.6**	**1.6**	**2.2**	(1+2ms)-CMA-ES [2]
Artif Bee Colony	7.7	8.3	4.9	15	365	408	619	522	498	507	Artif Bee Colony [8]
avg NEWUOA	**1.2**	**2.6**	**1.3**	**1.6**	**2.6**	**2.6**	**2.6**	**2.6**	**2.4**	**2.5**	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	5.0	54	241	657	518	518	372	300	220	230	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	4.8	7.1	6.5	7.6	8.5	8.1	7.0	6.5	5.3	5.4	Adap DE (F-AUC) [10]
DE (Uniform)	4.7	7.2	9.0	9.2	10	9.2	7.8	7.3	6.1	6.1	DE (Uniform) [9]
IPOP-aCMA-ES	**2.6**	5.3	**2.5**	**2.1**	**2.2**	**2.0**	**1.6**	**1.5**	**1.2**	**1.2**	IPOP-aCMA-ES [16]
IPOP-CMA-ES	**1.9**	3.2	**2.5**	**2.1**	**2.2**	**2.0**	**1.7**	**1.5**	**1.3**	**1.2**	IPOP-CMA-ES [22]
CMA+DE-MOS	11	11	8.0	8.6	8.8	7.7	6.3	5.7	4.8	4.6	CMA+DE-MOS [18]
NBC-CMA	9.2	8.5	8.2	19	16	11	8.4	6.8	5.1	4.3	NBC-CMA [21]
POEMS	102	81	26	46	54	51	45	43	36	37	POEMS [17]
PM-AdapSS-DE	6.0	7.4	8.1	8.1	9.0	8.3	7.3	6.7	5.7	5.7	PM-AdapSS-DE [9, 10]
pPOEMS	91	76	31	202	313	323	306	300	266	282	pPOEMS [17, 20]
Basic RCGA	29	28	26	72	255	434	598	*47e-4/5e4*	.	.	Basic RCGA [24]
SPSA	521	13582	28485	32769	25181	*44e+0/1e5*	.	.	.	.	SPSA [13]

Table 55: Running time excess ERT/$\text{ERT}_{\text{best 2009}}$ on f_7 in **5-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

7 Step-ellipsoid

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
ERT_{best}/D	0.20	1.2	4.7	65	234	290	314	314	314	319	ERT_{best}/D
(1,2)-CMA-ES	3.5	8.5	19	28	188	*17e-2/1e4*	.	.	.	.	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	**1.5**	4.0	7.2	5.3	11	50	225	225	225	221	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	**1.4**	**2.8**	5.8	5.0	17	40	81	81	81	104	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	**1.3**	8.6	37	39	187	*28e-2/1e4*	.	.	.	.	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	**1.6**	**2.3**	7.1	3.1	5.8	25	41	41	41	97	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	**1.4**	**2.9**	5.5	3.7	7.1	16	35	35	35	80	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	**1.4**	**1.7**	**4.1**	**1.9**	3.9	17	25	25	25	60	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	**1.8**	**2.8**	8.4	4.2	11	23	100	100	100	139	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	**2.3**	**2.1**	4.1	**2.8**	3.2	**3.0**	3.6	3.6	3.6	3.5	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	**2.0**	**1.8**	**3.7**	**2.6**	**1.4**	**1.7**	**1.9**	**1.9**	**1.9**	**1.8**	(1+2ms)-CMA-ES [2]
Artif Bee Colony	**1.1**	3.6	20	16	62	464	957	957	957	1359	Artif Bee Colony [8]
avg NEWUOA	**1.1**	**2.5**	4.4	5.9	13	131	*17e-3/8e3*	.	.	.	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	19	17	274	1509	6253	*94e-2/1e5*	.	.	.	.	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	**1.3**	**1.8**	13	**2.4**	**1.1**	**1.2**	**1.2**	**1.2**	**1.2**	**1.3**	Adap DE (F-AUC) [10]
DE (Uniform)	**1.5**	5.0	14	**2.7**	**1.2**	**1.5**	**1.4**	**1.4**	**1.4**	**1.6**	DE (Uniform) [9]
IPOP-aCMA-ES	**1.7**	3.1	**4.0**	**0.87**	**0.70**	**0.68**	**0.69**	**0.69**	**0.69**	**0.70**	IPOP-aCMA-ES [16]
IPOP-CMA-ES	**2.8**	**2.8**	4.4	**1.7**	**1.2**	**1.1**	**1.2**	**1.2**	**1.2**	**1.2**	IPOP-CMA-ES [22]
CMA+DE-MOS	**1.5**	3.0	13	5.1	**2.5**	**2.4**	**2.3**	**2.3**	**2.3**	**2.3**	CMA+DE-MOS [18]
NBC-CMA	**1.3**	**2.4**	7.0	7.2	6.1	5.0	4.7	4.7	4.7	4.7	NBC-CMA [21]
POEMS	200	187	83	17	9.0	11	11	11	11	12	POEMS [17]
PM-AdapSS-DE	**1.8**	**1.9**	12	**2.5**	**1.2**	**1.4**	**1.3**	**1.3**	**1.3**	**1.5**	PM-AdapSS-DE [9, 10]
pPOEMS	**1.4**	114	89	26	43	59	76	76	76	79	pPOEMS [17, 20]
Basic RCGA	**1.7**	3.1	25	73	147	336	690	690	690	1072	Basic RCGA [24]
SPSA	122	259	32256	*11e+0/1e5*	.	.	.	.	.	.	SPSA [13]

Table 56: Running time excess ERT/$\mathrm{ERT}_{\text{best 2009}}$ on f_8 in **5-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

8 Rosenbrock original

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
$\mathrm{ERT}_{\text{best}}$/D	3.6	8.8	15	55	67	74	78	80	82	84	$\mathrm{ERT}_{\text{best}}$/D
(1,2)-CMA-ES	6.5	12	10	10	14	14	15	15	15	15	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	4.1	5.7	5.6	5.7	7.2	7.8	8.1	8.3	8.4	8.7	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	5.2	4.5	4.2	5.8	6.8	7.3	7.5	7.6	7.6	7.8	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	7.8	15	12	14	19	19	20	20	21	21	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	**2.6**	**2.9**	**2.6**	4.9	5.7	5.8	5.9	6.1	6.2	6.3	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	**2.0**	3.2	**2.9**	3.6	4.3	4.7	4.8	5.0	5.0	5.2	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	**1.4**	**2.6**	**2.3**	**2.9**	**3.5**	**3.6**	**3.7**	**3.8**	**3.8**	**4.0**	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	**1.5**	**2.3**	**2.4**	4.1	5.0	5.2	5.4	5.4	5.5	5.6	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	**2.5**	**2.5**	**2.3**	3.5	3.8	3.8	3.8	3.9	4.0	4.1	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	**1.7**	**2.0**	**1.9**	3.0	**3.2**	**3.2**	**3.3**	**3.4**	**3.4**	**3.5**	(1+2ms)-CMA-ES [2]
Artif Bee Colony	4.4	5.0	6.0	12	52	449	2509	*10e-4/1e5*	.	.	Artif Bee Colony [8]
avg NEWUOA	**1.3**	**1.6**	**1.2**	**1.2**	**1.1**	**1.1**	**1.1**	**1.1**	**1.1**	**1.1**	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	11	9.0	8.2	7.6	8.2	8.5	8.8	9.3	10	11	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	6.5	11	13	8.9	11	11	11	12	13	14	Adap DE (F-AUC) [10]
DE (Uniform)	7.2	12	15	10	14	16	17	17	18	20	DE (Uniform) [9]
IPOP-aCMA-ES	**2.1**	**2.4**	**2.8**	**3.0**	3.6	3.8	4.0	4.1	4.2	4.5	IPOP-aCMA-ES [16]
IPOP-CMA-ES	**2.6**	3.8	3.5	4.8	5.3	5.5	5.6	5.7	5.8	6.1	IPOP-CMA-ES [22]
CMA+DE-MOS	6.3	6.8	11	11	12	13	13	14	14	15	CMA+DE-MOS [18]
NBC-CMA	4.4	7.5	7.1	7.0	8.1	8.4	8.6	8.8	8.9	9.3	NBC-CMA [21]
POEMS	66	40	58	52	117	380	689	1132	1485	2230	POEMS [17]
PM-AdapSS-DE	5.5	11	13	9.4	15	18	19	19	20	21	PM-AdapSS-DE [9, 10]
pPOEMS	56	36	84	262	365	482	583	689	795	1052	pPOEMS [17, 20]
Basic RCGA	5.7	12	32	558	1450	2992	2983	9295	*54e-2/5e4*	.	Basic RCGA [24]
SPSA	360	1473	3764	12308	*50e-1/1e5*	.	.	.	.	.	SPSA [13]

Table 57: Running time excess ERT/$\text{ERT}_{\text{best 2009}}$ on f_9 in **5-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

9 Rosenbrock rotated

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
ERT_{best}/D	0.20	0.20	6.9	25	43	53	60	65	67	74	ERT_{best}/D
(1,2)-CMA-ES	131	285	12	27	24	23	21	21	20	19	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	62	164	7.4	14	12	12	11	11	11	10	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	57	273	14	12	11	10	10	9.3	9.2	8.8	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	98	382	16	51	40	37	34	33	33	31	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	31	218	9.0	14	11	10	9.4	9.1	9.0	8.6	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	30	111	5.2	9.5	8.2	7.6	7.2	7.0	7.0	6.7	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	26	117	5.4	10	7.7	6.8	6.3	6.1	6.0	5.8	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	28	128	5.7	11	9.2	8.3	7.7	7.4	7.3	6.9	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	**22**	**65**	**3.3**	13	9.0	7.8	7.2	6.8	6.8	6.4	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	**25**	102	**4.6**	**6.2**	**5.0**	**4.4**	**4.2**	**4.0**	**4.0**	**3.9**	(1+2ms)-CMA-ES [2]
Artif Bee Colony	86	259	14	69	699	3988	*13e-3/1e5*	.	.	.	Artif Bee Colony [8]
avg NEWUOA	**20**	**56**	**2.4**	**3.1**	**2.1**	**1.8**	**1.7**	**1.6**	**1.6**	**1.5**	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	276	692	48	79	56	50	45	46	46	45	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	97	393	24	18	16	16	16	16	16	17	Adap DE (F-AUC) [10]
DE (Uniform)	143	444	30	23	21	22	21	21	22	22	DE (Uniform) [9]
IPOP-aCMA-ES	28	97	5.4	**6.2**	**5.7**	**5.3**	**5.0**	**4.9**	**5.0**	**4.9**	IPOP-aCMA-ES [16]
IPOP-CMA-ES	29	**92**	6.0	11	8.7	7.9	7.5	7.3	7.3	7.2	IPOP-CMA-ES [22]
CMA+DE-MOS	98	367	13	10	17	18	17	17	17	17	CMA+DE-MOS [18]
NBC-CMA	84	281	15	11	11	10	10	9.5	10	9.5	NBC-CMA [21]
POEMS	1148	1606	109	116	176	616	1039	1473	1856	2809	POEMS [17]
PM-AdapSS-DE	90	374	25	22	21	22	21	21	21	22	PM-AdapSS-DE [9, 10]
pPOEMS	1126	1981	287	563	596	630	722	850	994	1200	pPOEMS [17, 20]
Basic RCGA	118	318	40	8950	*17e-1/5e4*	.	.	.	.	.	Basic RCGA [24]
SPSA	8379	1.78e5	13128	56959	*54e-1/1e5*	.	.	.	.	.	SPSA [13]

Table 58: Running time excess $\mathrm{ERT}/\mathrm{ERT}_{\text{best 2009}}$ on f_{10} in **5-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

10 Ellipsoid

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
$\mathrm{ERT}_{\text{best}}$/D	21	34	70	100	115	121	125	129	166	176	$\mathrm{ERT}_{\text{best}}$/D
(1,2)-CMA-ES	21	23	16	12	11	10	10	10	8.2	8.0	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	15	13	9.4	7.6	6.8	6.6	6.5	6.5	5.1	5.1	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	12	11	7.3	5.8	5.4	5.2	5.2	5.1	4.1	4.0	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	21	25	19	14	13	13	13	12	10	10	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	6.3	6.4	5.0	4.1	3.9	3.9	3.9	3.8	3.1	3.0	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	7.2	7.3	4.5	3.6	3.3	3.3	3.4	3.4	**2.7**	**2.7**	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	4.7	3.8	3.1	**2.6**	**2.6**	**2.5**	**2.5**	**2.5**	**2.0**	**2.0**	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	4.3	5.5	3.7	3.2	3.1	3.1	3.1	3.1	**2.5**	**2.5**	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	**3.7**	**3.4**	**2.6**	**2.1**	**2.1**	**2.0**	**2.0**	**2.1**	**1.7**	**1.7**	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	**2.4**	**2.9**	**2.2**	**1.7**	**1.7**	**1.7**	**1.7**	**1.7**	**1.4**	**1.4**	(1+2ms)-CMA-ES [2]
Artif Bee Colony	195	2201	21228	*55e+0/1e5*	.	.	.	.	.	.	Artif Bee Colony [8]
avg NEWUOA	**1.2**	**2.2**	3.1	4.6	6.6	8.1	10	12	11	14	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	22	23	16	12	11	11	10	10	8.2	8.1	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	7.1	6.5	4.5	3.9	4.0	4.5	4.9	5.4	4.7	5.3	Adap DE (F-AUC) [10]
DE (Uniform)	7.7	6.9	4.5	4.2	4.6	5.1	5.5	6.1	5.4	6.2	DE (Uniform) [9]
IPOP-aCMA-ES	3.8	3.7	**2.5**	**2.2**	**2.1**	**2.1**	**2.2**	**2.2**	**1.8**	**1.9**	IPOP-aCMA-ES [16]
IPOP-CMA-ES	4.6	4.3	3.6	**2.9**	**2.7**	**2.7**	**2.8**	**2.8**	**2.3**	**2.3**	IPOP-CMA-ES [22]
CMA+DE-MOS	13	13	10	8.1	7.6	7.6	7.7	7.9	6.4	6.5	CMA+DE-MOS [18]
NBC-CMA	6.2	6.7	4.6	4.5	4.4	4.4	4.5	4.6	3.8	3.8	NBC-CMA [21]
POEMS	54	408	1411	4129	17335	*24e-1/3e5*	.	.	.	.	POEMS [17]
PM-AdapSS-DE	6.6	6.5	4.6	4.0	4.3	4.8	5.3	5.9	5.2	5.9	PM-AdapSS-DE [9, 10]
pPOEMS	59	343	552	639	738	844	1002	1180	1040	1238	pPOEMS [17, 20]
Basic RCGA	460	1563	3242	*72e+0/5e4*	.	.	.	.	.	.	Basic RCGA [24]
SPSA	5248	*73e+1/1e5*	.	.	.	.	.	.	.	.	SPSA [13]

Table 59: Running time excess ERT/ERT$_{\text{best 2009}}$ on f_{11} in **5-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

11 Discus

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
ERT$_{\text{best}}$/D	2.5	4.9	29	40	153	195	235	270	293	335	ERT$_{\text{best}}$/D
(1,2)-CMA-ES	31	91	28	25	7.3	6.0	5.1	4.5	4.3	3.9	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	25	91	24	20	5.6	4.6	3.9	3.5	3.3	**3.0**	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	37	59	19	16	4.8	3.9	3.3	**3.0**	**2.8**	**2.6**	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	6.8	88	31	29	9.1	7.3	6.3	5.6	5.3	4.9	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	**3.9**	20	10	10	**2.9**	**2.3**	**2.0**	**1.8**	**1.7**	**1.6**	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	5.7	39	12	10	**2.8**	**2.3**	**2.0**	**1.8**	**1.7**	**1.6**	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	5.7	37	10	7.9	**2.2**	**1.8**	**1.5**	**1.4**	**1.3**	**1.2**	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	17	31	10	8.1	**2.3**	**1.9**	**1.7**	**1.5**	**1.4**	**1.3**	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	4.0	12	5.8	6.9	**2.1**	**1.8**	**1.5**	**1.3**	**1.3**	**1.2**	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	**4.0**	**7.7**	**4.9**	**5.2**	**1.7**	**1.4**	**1.2**	**1.1**	**1.1**	**0.98**	(1+2ms)-CMA-ES [2]
Artif Bee Colony	6.1	**8.5**	160	6088	9336	*15e-1/1e5*	.	.	.	.	Artif Bee Colony [8]
avg NEWUOA	**2.6**	11	**5.4**	7.2	**2.7**	**2.6**	**2.8**	**2.9**	3.1	3.4	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	10	180	61	51	14	11	9.0	8.0	7.4	6.7	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	12	12	6.2	6.6	**2.2**	**2.1**	**2.0**	**2.1**	**2.2**	**2.4**	Adap DE (F-AUC) [10]
DE (Uniform)	10	14	6.2	6.6	**2.4**	**2.3**	**2.4**	**2.4**	**2.6**	**2.8**	DE (Uniform) [9]
IPOP-aCMA-ES	7.1	12	**5.6**	**4.7**	**1.4**	**1.2**	**1.0**	**0.97**	**0.95**	**0.92**	IPOP-aCMA-ES [16]
IPOP-CMA-ES	5.9	17	8.6	7.3	**2.1**	**1.8**	**1.6**	**1.4**	**1.4**	**1.3**	IPOP-CMA-ES [22]
CMA+DE-MOS	8.0	13	18	17	4.9	4.2	3.7	3.4	3.3	3.2	CMA+DE-MOS [18]
NBC-CMA	8.4	13	13	14	4.1	3.4	**3.0**	**2.7**	**2.6**	**2.4**	NBC-CMA [21]
POEMS	78	44	558	918	466	496	571	571	680	739	POEMS [17]
PM-AdapSS-DE	11	15	6.3	**6.5**	**2.3**	**2.2**	**2.3**	**2.3**	**2.4**	**2.7**	PM-AdapSS-DE [9, 10]
pPOEMS	80	50	95	393	204	232	251	261	291	341	pPOEMS [17, 20]
Basic RCGA	10	**11**	473	5466	*26e-1/5e4*	.	.	.	.	.	Basic RCGA [24]
SPSA	21	8415	49100	*63e+0/1e5*	.	.	.	.	.	.	SPSA [13]

Table 60: Running time excess ERT/ERT$_{\text{best 2009}}$ on f_{12} in **5-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

12 Bent cigar

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
ERT$_{\text{best}}$/D	13	16	22	54	74	83	92	233	261	299	ERT$_{\text{best}}$/D
(1,2)-CMA-ES	6.4	19	33	26	24	25	24	11	10	10	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	6.7	10	25	16	14	14	14	6.2	6.0	5.9	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	4.3	11	20	15	14	14	13	5.6	5.4	5.2	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	6.4	30	44	38	45	46	45	25	23	23	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	3.7	7.5	14	9.0	8.9	8.9	8.6	3.8	3.6	3.5	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	3.5	5.7	14	10	10	10	10	4.4	4.2	4.1	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	**2.8**	4.6	15	10	8.9	8.9	8.6	3.7	3.5	3.3	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	**3.0**	5.5	10	8.2	8.7	9.0	9.0	4.0	3.9	3.8	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	**2.9**	**3.3**	**7.8**	6.8	6.9	7.2	6.9	3.0	3.1	3.0	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	**2.7**	**3.4**	**6.0**	**4.2**	**4.0**	**4.2**	**4.2**	**1.8**	**1.8**	**1.8**	(1+2ms)-CMA-ES [2]
Artif Bee Colony	16	35	99	547	5852	*29e-2/1e5*	.	.	.	.	Artif Bee Colony [8]
avg NEWUOA	**1.1**	**1.8**	**3.5**	**2.8**	**2.8**	**2.9**	**3.0**	**1.3**	**1.3**	**1.4**	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	11	30	52	35	32	32	31	13	40	36	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	23	24	22	13	13	13	14	6.4	6.4	6.6	Adap DE (F-AUC) [10]
DE (Uniform)	27	29	28	21	21	22	22	10	10	11	DE (Uniform) [9]
IPOP-aCMA-ES	4.6	5.0	8.8	**5.9**	**5.7**	**6.0**	**6.0**	**2.6**	**2.6**	**2.6**	IPOP-aCMA-ES [16]
IPOP-CMA-ES	5.2	5.2	9.4	6.1	6.2	6.4	6.3	**2.8**	**2.8**	**2.8**	IPOP-CMA-ES [22]
CMA+DE-MOS	21	21	25	16	16	16	16	7.1	6.9	6.8	CMA+DE-MOS [18]
NBC-CMA	18	17	17	10	12	12	12	5.5	5.5	5.5	NBC-CMA [21]
POEMS	183	222	9450	6512	56748	50936	45608	18045	*16e-1/3e5*	.	POEMS [17]
PM-AdapSS-DE	22	25	24	16	24	27	27	12	12	13	PM-AdapSS-DE [9, 10]
pPOEMS	934	1481	2087	1366	1384	1554	1879	917	1009	1369	pPOEMS [17, 20]
Basic RCGA	76	91	423	665	1672	8906	7980	*29e-2/5e4*	.	.	Basic RCGA [24]
SPSA	2659	4809	18513	*75e+0/1e5*	.	.	.	.	.	.	SPSA [13]

Table 61: Running time excess ERT/ERT$_{\text{best 2009}}$ on f_{13} in **5-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

13 Sharp ridge

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
ERT$_{\text{best}}$/D	0.56	8.9	26	39	50	64	262	305	350	451	ERT$_{\text{best}}$/D
(1,2)-CMA-ES	7.1	15	25	27	37	65	22	22	28	98	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	**2.0**	4.2	9.4	30	34	34	14	16	27	37	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	5.9	3.1	4.6	17	21	24	14	16	18	36	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	7.7	7.6	16	32	44	60	23	24	46	153	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	**2.6**	3.6	7.0	10	11	10	3.0	3.1	4.2	5.1	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	5.8	3.3	6.4	11	10	9.1	**2.8**	3.1	3.2	3.9	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	**2.5**	4.3	**2.9**	**4.9**	7.7	6.7	**2.5**	3.5	3.1	3.1	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	3.1	3.1	5.0	10	10	8.8	3.3	3.1	3.1	5.0	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	**2.4**	**2.2**	3.7	7.1	8.3	7.9	**2.4**	**2.2**	**2.2**	3.1	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	**1.9**	**2.1**	**3.1**	7.9	**7.1**	**6.1**	**1.9**	**2.0**	**2.0**	**2.3**	(1+2ms)-CMA-ES [2]
Artif Bee Colony	**1.9**	11	18	187	6618	*15e-2/1e5*	.	.	.	.	Artif Bee Colony [8]
avg NEWUOA	4.0	**1.0**	4.5	8.1	42	67	68	450	391	*15e-4/9e3*	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	28	30	506	1310	8016	10188	5347	*38e-2/1e5*	.	.	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	**2.9**	14	10	11	11	11	3.2	3.3	3.2	3.1	Adap DE (F-AUC) [10]
DE (Uniform)	**2.3**	15	11	12	13	13	3.7	3.8	3.8	3.7	DE (Uniform) [9]
IPOP-aCMA-ES	**2.6**	3.3	**3.0**	**4.1**	**4.2**	**4.0**	**1.2**	**1.2**	**1.2**	**1.1**	IPOP-aCMA-ES [16]
IPOP-CMA-ES	3.8	4.0	3.1	**5.0**	**5.3**	**5.1**	**1.4**	**1.6**	**1.6**	**1.6**	IPOP-CMA-ES [22]
CMA+DE-MOS	**1.7**	15	11	12	14	13	3.5	3.4	3.4	3.2	CMA+DE-MOS [18]
NBC-CMA	**1.8**	9.5	6.2	7.5	9.3	9.3	**2.6**	**2.6**	**2.7**	**2.6**	NBC-CMA [21]
POEMS	286	52	904	2912	9139	18912	16068	13841	*12e-2/3e5*	.	POEMS [17]
PM-AdapSS-DE	**2.1**	13	10	11	12	12	3.4	3.5	3.5	3.4	PM-AdapSS-DE [9, 10]
pPOEMS	26	57	446	793	1067	1220	390	472	1316	9956	pPOEMS [17, 20]
Basic RCGA	**2.4**	34	282	1074	6915	11505	*50e-2/5e4*	.	.	.	Basic RCGA [24]
SPSA	22	55	2055	*43e-1/1e5*	.	.	.	.	.	.	SPSA [13]

Table 62: Running time excess ERT/ERT$_{\text{best 2009}}$ on f_{14} in **5-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

14 Sum of different powers

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
ERT$_{\text{best}}$/D	0.20	0.20	2.0	8.2	12	18	28	42	50	95	ERT$_{\text{best}}$/D
(1,2)-CMA-ES	**1**	**1.8**	**2.3**	5.0	5.9	6.3	8.3	11	13	13	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	**1**	**1**	4.3	3.5	3.9	4.3	5.8	8.2	11	9.3	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	**1**	**1.8**	3.1	3.2	3.3	3.6	4.8	6.9	9.2	8.1	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	**1**	**1.2**	3.5	6.4	6.4	6.3	11	14	17	16	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	**1**	**1.6**	**1.7**	**1.9**	3.1	3.2	4.2	5.0	6.8	5.4	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	**1**	**1.6**	**2.3**	**2.1**	**2.9**	3.3	3.9	4.6	6.0	5.3	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	**1**	**1.5**	**1.7**	**1.8**	**2.3**	**2.3**	**2.9**	3.6	4.5	4.0	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	**1**	**2.5**	**2.0**	**2.0**	**2.5**	3.0	3.8	4.2	5.2	4.7	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	**1**	**1.6**	**1.2**	**1.8**	**2.3**	**2.5**	**2.7**	**3.1**	**4.1**	**3.3**	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	**1**	**1.6**	**0.82**	**1.4**	**1.7**	**2.0**	**2.7**	**2.9**	**3.2**	**2.7**	(1+2ms)-CMA-ES [2]
Artif Bee Colony	**1**	**1.9**	3.5	11	19	29	679	33788	*27e-5/1e5*	.	Artif Bee Colony [8]
avg NEWUOA	**1**	**1.7**	**2.1**	**1.0**	**1.0**	**1.0**	**1.2**	**1.8**	5.0	1029	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	4.1	25	14	7.3	7.5	8.8	17	21	27	203	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	**1**	**1.3**	**2.2**	9.4	15	15	13	11	11	8.2	Adap DE (F-AUC) [10]
DE (Uniform)	**1**	**1.2**	**2.3**	10	16	18	15	13	13	9.3	DE (Uniform) [9]
IPOP-aCMA-ES	**1**	**2.3**	**1.5**	**2.2**	3.2	3.6	3.6	3.4	**3.8**	**2.9**	IPOP-aCMA-ES [16]
IPOP-CMA-ES	**1**	**1.3**	**2.2**	**2.9**	3.8	4.3	4.7	4.7	5.4	4.4	IPOP-CMA-ES [22]
CMA+DE-MOS	**1**	**1.2**	**2.9**	13	14	15	14	13	14	11	CMA+DE-MOS [18]
NBC-CMA	**1**	**1.3**	**1.4**	7.0	8.7	8.1	7.4	6.6	7.7	6.4	NBC-CMA [21]
POEMS	**1**	280	111	43	79	124	136	130	501	*46e-8/3e5*	POEMS [17]
PM-AdapSS-DE	**1**	**1.5**	**1**	9.4	17	17	15	12	12	8.9	PM-AdapSS-DE [9, 10]
pPOEMS	**1**	69	61	47	140	597	798	868	1057	2134	pPOEMS [17, 20]
Basic RCGA	**1**	**1.1**	**1.5**	23	40	59	273	1453	14895	*90e-6/5e4*	Basic RCGA [24]
SPSA	24	120	167	106	86	69	99	601	2141	*60e-7/1e5*	SPSA [13]

Table 63: Running time excess ERT/$\mathrm{ERT}_{\mathrm{best\ 2009}}$ on f_{15} in **5-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

15 Rastrigin

Δftarget $\mathrm{ERT}_{\mathrm{best}}$/D	1e+03 0.20	1e+02 2.6	1e+01 102	1e+00 1862	1e-01 3874	1e-02 3949	1e-03 4015	1e-04 4084	1e-05 4154	1e-07 4272	Δftarget $\mathrm{ERT}_{\mathrm{best}}$/D
(1,2)-CMA-ES	**1.5**	5.7	27	76	*50e-1/1e4*	.	.	.	.	.	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	**1**	**2.2**	8.1	26	*30e-1/1e4*	.	.	.	.	.	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	**1**	**1.8**	11	25	*30e-1/1e4*	.	.	.	.	.	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	**1.1**	6.5	129	*99e-1/1e4*	.	.	.	.	.	.	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	**1.5**	**2.9**	8.2	38	*20e-1/1e4*	.	.	.	.	.	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	**1.3**	**2.5**	3.7	18	*20e-1/1e4*	.	.	.	.	.	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	**1.1**	**1.5**	**2.8**	13	38	37	36	36	35	34	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	**1.7**	7.3	8.5	40	*30e-1/1e4*	.	.	.	.	.	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	**1.5**	**2.3**	6.1	*20e-1/1e4*	.	.	.	.	.	.	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	**1**	**1.2**	4.6	38	*20e-1/1e4*	.	.	.	.	.	(1+2ms)-CMA-ES [2]
Artif Bee Colony	**1.1**	**2.8**	15	243	*11e-1/1e5*	.	.	.	.	.	Artif Bee Colony [8]
avg NEWUOA	**1.3**	**2.0**	5.8	46	*30e-1/6e3*	.	.	.	.	.	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	15	7.1	8.6	95	185	366	361	354	*20e-1/1e5*	.	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	**1.1**	3.8	5.4	**2.0**	7.5	7.4	7.3	7.2	7.1	6.9	Adap DE (F-AUC) [10]
DE (Uniform)	**1.2**	4.5	4.8	**2.2**	3.0	**3.0**	**3.0**	**2.9**	**2.9**	**2.9**	DE (Uniform) [9]
IPOP-aCMA-ES	**1**	**2.3**	**1.5**	**0.89**	**1.0**	**1.0**	**1.0**	**1.0**	**1.0**	**1.0**	IPOP-aCMA-ES [16]
IPOP-CMA-ES	**1.3**	**1.3**	**2.3**	**1.3**	**1.2**	**1.2**	**1.2**	**1.2**	**1.2**	**1.2**	IPOP-CMA-ES [22]
CMA+DE-MOS	**1.1**	**2.5**	4.3	**1.4**	**1.6**	**1.6**	**1.6**	**1.6**	**1.6**	**1.6**	CMA+DE-MOS [18]
NBC-CMA	**1.1**	**2.7**	**2.3**	4.3	16	16	15	15	15	14	NBC-CMA [21]
POEMS	154	92	18	232	335	329	324	319	314	305	POEMS [17]
PM-AdapSS-DE	**1.4**	**2.4**	5.4	6.3	3.2	3.2	3.2	3.3	7.6	7.4	PM-AdapSS-DE [9, 10]
pPOEMS	**1.3**	73	57	29	60	61	62	63	64	66	pPOEMS [17, 20]
Basic RCGA	**1.1**	3.1	25	9.4	12	12	12	12	15	20	Basic RCGA [24]
SPSA	35780	5960	2251	*13e+0/1e5*	.	.	.	.	.	.	SPSA [13]

Table 64: Running time excess ERT/ERT$_{\text{best 2009}}$ on f_{16} in **5-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

16 Weierstrass

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
ERT$_{\text{best}}$/D	0.20	0.24	24	122	532	2033	2090	2283	2329	2419	ERT$_{\text{best}}$/D
(1,2)-CMA-ES	**1**	**1.4**	42	259	*14e-1/1e4*	.	.	.	.	.	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	**1**	**1**	16	29	45	70	69	63	62	*18e-2/1e4*	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	**1**	**1.2**	15	43	38	36	*17e-2/1e4*	.	.	.	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	**1**	**1.3**	58	589	*28e-1/1e4*	.	.	.	.	.	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	**1**	**1.1**	7.2	27	31	34	*22e-2/1e4*	.	.	.	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	**1**	**1.3**	**2.9**	5.8	12	6.1	11	29	*98e-4/1e4*	.	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	**1**	**1.5**	5.6	16	19	15	33	*39e-3/1e4*	.	.	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	**1**	**1.8**	8.1	20	33	72	*14e-2/1e4*	.	.	.	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	**1**	**1.2**	**2.0**	21	19	33	*71e-3/1e4*	.	.	.	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	**1**	**1.2**	**1.7**	7.7	16	*62e-3/1e4*	.	.	.	.	(1+2ms)-CMA-ES [2]
Artif Bee Colony	**1**	**1.7**	**2.3**	10	95	*48e-3/1e5*	.	.	.	.	Artif Bee Colony [8]
avg NEWUOA	**1**	**1.2**	**2.6**	12	47	*35e-2/8e3*	.	.	.	.	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	**1.3**	20	7.8	179	409	324	671	*15e-2/1e5*	.	.	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	**1**	**1.2**	6.4	39	31	8.2	12	11	11	10	Adap DE (F-AUC) [10]
DE (Uniform)	**1**	**1.2**	4.3	44	20	13	17	16	16	15	DE (Uniform) [9]
IPOP-aCMA-ES	**1**	**1.1**	3.9	**2.4**	**1.7**	**0.56**	**0.82**	**0.84**	**0.84**	**0.85**	IPOP-aCMA-ES [16]
IPOP-CMA-ES	**1**	**1.3**	**2.5**	**2.3**	**1.7**	**0.55**	**0.96**	**0.94**	**0.94**	**0.95**	IPOP-CMA-ES [22]
CMA+DE-MOS	**1**	**1.6**	**1.6**	**2.9**	**2.6**	**1.2**	**1.2**	**1.2**	7.7	7.7	CMA+DE-MOS [18]
NBC-CMA	**1**	**1.3**	3.0	4.0	**1.3**	**0.81**	**0.86**	**0.84**	**0.83**	**0.83**	NBC-CMA [21]
POEMS	**1**	57	11	14	92	56	74	68	68	66	POEMS [17]
PM-AdapSS-DE	**1**	**1.3**	3.9	124	55	16	20	18	28	27	PM-AdapSS-DE [9, 10]
pPOEMS	**1**	**1.5**	10	52	40	53	116	110	113	116	pPOEMS [17, 20]
Basic RCGA	**1**	**1.4**	**2.4**	60	49	80	351	322	*16e-3/5e4*	.	Basic RCGA [24]
SPSA	4.3	280	548	1367	594	349	695	*12e-1/1e5*	.	.	SPSA [13]

Table 65: Running time excess ERT/ERT$_{\text{best 2009}}$ on f_{17} in **5-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

17 Schaffer F7, condition 10

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
ERT$_{\text{best}}$/D	0.20	0.20	1.0	43	180	572	734	959	1270	1587	ERT$_{\text{best}}$/D
(1,2)-CMA-ES	**1**	**1.1**	52	54	404	*14e-2/1e4*	.	.	.	.	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	**1**	**1.3**	6.7	5.3	6.2	13	64	*51e-4/1e4*	.	.	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	**1**	**1.3**	5.3	5.0	13	22	*87e-4/1e4*	.	.	.	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	**1**	**1.3**	52	87	397	*36e-2/1e4*	.	.	.	.	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	**1**	**1**	116	20	18	31	*27e-3/1e4*	.	.	.	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	**1**	**1**	20	**2.3**	4.1	7.2	90	*34e-4/1e4*	.	.	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	**1**	**1.1**	5.1	**0.71**	4.5	28	*12e-3/1e4*	.	.	.	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	**1**	**1**	4.2	3.6	18	54	*23e-3/1e4*	.	.	.	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	**1**	**1**	15	25	94	*14e-2/1e4*	.	.	.	.	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	**1**	**1.2**	15	17	24	*38e-3/1e4*	.	.	.	.	(1+2ms)-CMA-ES [2]
Artif Bee Colony	**1**	**1.1**	6.5	15	64	1259	*31e-3/1e5*	.	.	.	Artif Bee Colony [8]
avg NEWUOA	**1**	**1.2**	**3.1**	42	405	*24e-2/1e4*	.	.	.	.	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	17	37	17	3.3	**2.5**	40	62	120	1104	*36e-5/1e5*	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	**1**	**1.2**	5.7	3.9	**2.3**	**1.2**	**1.3**	**1.3**	**1.3**	**1.4**	Adap DE (F-AUC) [10]
DE (Uniform)	**1**	**1**	3.8	4.3	**2.7**	**1.4**	**1.6**	**1.6**	**1.5**	**1.6**	DE (Uniform) [9]
IPOP-aCMA-ES	**1**	**1.3**	4.3	**0.89**	**0.53**	**0.59**	**0.77**	**0.74**	**1.00**	**1.1**	IPOP-aCMA-ES [16]
IPOP-CMA-ES	**1**	**1.1**	4.8	**1.1**	**0.97**	**0.61**	**0.77**	**0.80**	**0.81**	**1.0**	IPOP-CMA-ES [22]
CMA+DE-MOS	**1**	**1.1**	**2.8**	5.8	5.2	3.9	5.4	4.7	3.9	4.0	CMA+DE-MOS [18]
NBC-CMA	**1**	**1.2**	5.6	**2.2**	**1.9**	**0.74**	**0.68**	**0.68**	**1.6**	3.3	NBC-CMA [21]
POEMS	**1**	78	221	17	15	8.2	14	61	98	139	POEMS [17]
PM-AdapSS-DE	**1**	**1.3**	4.2	4.0	**2.3**	**1.2**	**1.4**	**1.4**	**1.3**	**1.4**	PM-AdapSS-DE [9, 10]
pPOEMS	**1**	**1.3**	169	22	88	57	71	75	73	82	pPOEMS [17, 20]
Basic RCGA	**1**	**1.1**	**2.9**	57	48	35	56	124	173	*30e-5/5e4*	Basic RCGA [24]
SPSA	35977	77306	48618	2098	2228	2447	*85e-2/1e5*	.	.	.	SPSA [13]

Table 66: Running time excess $\mathrm{ERT}/\mathrm{ERT}_{\text{best 2009}}$ on f_{18} in **5-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

18 Schaffer F7, condition 1000

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
$\mathrm{ERT}_{\text{best}}/D$	0.20	0.24	21	76	794	1690	1856	2076	2181	2494	$\mathrm{ERT}_{\text{best}}/D$
(1,2)-CMA-ES	**1.1**	**2.4**	36	201	*11e-1/1e4*	.	.	.	.	.	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	**1**	4.7	3.7	28	23	*16e-2/1e4*	.	.	.	.	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	**1**	5.4	8.2	27	21	83	*13e-2/1e4*	.	.	.	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	**1**	7.6	29	601	*19e-1/1e4*	.	.	.	.	.	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	**1**	3.5	**3.0**	31	21	84	*14e-2/1e4*	.	.	.	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	**1**	**2.1**	**1.9**	5.9	9.2	19	*67e-3/1e4*	.	.	.	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	**1**	**2.7**	3.1	18	6.4	84	*39e-3/1e4*	.	.	.	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	**1**	5.4	8.8	35	20	*13e-2/1e4*	.	.	.	.	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	**1**	4.1	8.6	52	87	*42e-2/1e4*	.	.	.	.	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	**1.1**	3.6	15	48	33	85	*14e-2/1e4*	.	.	.	(1+2ms)-CMA-ES [2]
Artif Bee Colony	**1.1**	**1.6**	5.0	27	300	*14e-2/1e5*	.	.	.	.	Artif Bee Colony [8]
avg NEWUOA	**1**	5.4	10	272	*57e-2/3e4*	.	.	.	.	.	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	28	53	**2.2**	7.2	25	122	*22e-3/1e5*	.	.	.	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	**1**	**2.4**	4.3	3.8	**0.75**	**0.55**	**0.69**	**0.75**	**0.88**	**0.98**	Adap DE (F-AUC) [10]
DE (Uniform)	**1**	**2.7**	4.0	4.3	**0.81**	**0.58**	**0.73**	**0.80**	**0.95**	**1.1**	DE (Uniform) [9]
IPOP-aCMA-ES	**1**	5.8	3.5	**1.6**	**0.70**	**0.69**	**0.77**	**0.73**	**0.80**	**0.84**	IPOP-aCMA-ES [16]
IPOP-CMA-ES	**1.6**	7.5	**1.2**	**2.7**	**0.87**	**1.1**	**1.0**	**0.98**	**1.0**	**0.99**	IPOP-CMA-ES [22]
CMA+DE-MOS	**1.1**	**1.7**	4.9	6.7	**2.9**	**1.7**	**1.7**	**1.6**	**1.6**	**2.0**	CMA+DE-MOS [18]
NBC-CMA	**1**	**2.3**	3.1	**3.0**	**0.41**	**0.48**	**1.2**	3.4	6.2	15	NBC-CMA [21]
POEMS	**2.5**	260	19	23	33	207	449	2029	*15e-3/3e5*	.	POEMS [17]
PM-AdapSS-DE	**1.1**	4.4	4.3	4.1	**0.76**	**0.54**	**0.67**	**0.74**	**0.89**	**1.0**	PM-AdapSS-DE [9, 10]
pPOEMS	**1.1**	77	18	95	34	30	39	46	55	69	pPOEMS [17, 20]
Basic RCGA	**1**	3.5	7.9	88	23	35	187	347	*53e-4/5e4*	.	Basic RCGA [24]
SPSA	3.33e5	6.26e5	19476	18540	*31e+1/1e5*	.	.	.	.	.	SPSA [13]

Table 67: Running time excess ERT/$\text{ERT}_{\text{best 2009}}$ on f_{19} in **5-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

19 Griewank-Rosenbrock F8F2

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
ERT_{best}/D	0.20	0.20	0.20	0.20	48	20972	24088	24169	24229	24404	ERT_{best}/D
(1,2)-CMA-ES	**1**	**1**	31	16363	*56e-2/1e4*	.	.	.	.	.	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	**1**	**1**	62	4556	945	*27e-2/1e4*	.	.	.	.	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	**1**	**1.4**	22	8527	1393	*39e-2/1e4*	.	.	.	.	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	**1**	**1**	55	25341	*59e-2/1e4*	.	.	.	.	.	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	**1**	**1**	21	6463	*39e-2/1e4*	.	.	.	.	.	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	**1**	**1**	20	8960	659	*19e-2/1e4*	.	.	.	.	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	**1**	**1**	**17**	3093	478	7.0	6.1	6.1	6.0	6.0	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	**1**	**1**	25	10110	*34e-2/1e4*	.	.	.	.	.	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	**1**	**1**	**13**	5123	1482	*20e-2/1e4*	.	.	.	.	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	**1**	**1**	**17**	6018	233	*98e-3/1e4*	.	.	.	.	(1+2ms)-CMA-ES [2]
Artif Bee Colony	**1**	**1.2**	34	2898	3823	69	*12e-2/1e5*	.	.	.	Artif Bee Colony [8]
avg NEWUOA	**1**	**1**	24	15619	995	*55e-3/1e5*	.	.	.	.	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	17	37	97	5695	2016	33	*73e-3/1e5*	.	.	.	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	**1**	**1.1**	29	2586	1726	10	11	11	11	10	Adap DE (F-AUC) [10]
DE (Uniform)	**1**	**1.2**	35	3449	1630	15	13	13	13	13	DE (Uniform) [9]
IPOP-aCMA-ES	**1**	**1**	**14**	**1207**	**123**	**0.84**	**0.95**	**0.95**	**0.96**	**0.96**	IPOP-aCMA-ES [16]
IPOP-CMA-ES	**1**	**1**	21	1720	**125**	**1.2**	**1.1**	**1.1**	**1.1**	**1.1**	IPOP-CMA-ES [22]
CMA+DE-MOS	**1**	**1.2**	27	**658**	**108**	**3.9**	**4.8**	**4.8**	**4.8**	**4.8**	CMA+DE-MOS [18]
NBC-CMA	**1**	**1.1**	39	2946	2141	40	35	35	35	35	NBC-CMA [21]
POEMS	**1**	202	1047	30587	10531	98	87	86	86	86	POEMS [17]
PM-AdapSS-DE	**1**	**1.7**	37	2000	2054	22	19	19	19	29	PM-AdapSS-DE [9, 10]
pPOEMS	**1**	**1.1**	982	18467	1645	12	27	27	27	27	pPOEMS [17, 20]
Basic RCGA	**1**	**1.1**	33	**1019**	463	*63e-3/5e4*	.	.	.	.	Basic RCGA [24]
SPSA	36	97	422	2.10e5	29091	*59e-2/1e5*	.	.	.	.	SPSA [13]

Table 68: Running time excess $\mathrm{ERT}/\mathrm{ERT}_{\text{best 2009}}$ on f_{20} in **5-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

20 Schwefel x*sin(x)

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
$\mathrm{ERT}_{\text{best}}$/D	2.7	3.0	3.2	170	7622	10272	10894	10921	10972	11063	$\mathrm{ERT}_{\text{best}}$/D
(1,2)-CMA-ES	3.4	4.1	4.7	19	*67e-2/1e4*	.	.	.	.	.	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	**2.9**	4.0	4.5	11	*67e-2/1e4*	.	.	.	.	.	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	3.4	4.5	4.7	9.3	18	14	13	13	13	13	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	5.3	8.2	8.9	14	*67e-2/1e4*	.	.	.	.	.	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	**2.3**	3.3	3.3	10	9.4	7.0	6.6	6.6	6.6	6.5	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	**1.6**	**2.5**	**2.8**	6.9	*47e-2/1e4*	.	.	.	.	.	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	**1.8**	**2.5**	**2.6**	7.6	*47e-2/1e4*	.	.	.	.	.	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	**1.8**	**2.6**	**2.8**	6.8	*47e-2/1e4*	.	.	.	.	.	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	**2.2**	**2.7**	**2.8**	10	19	14	13	13	13	13	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	**1.7**	**2.2**	**2.6**	5.4	19	14	13	13	13	13	(1+2ms)-CMA-ES [2]
Artif Bee Colony	4.5	6.3	7.2	**1.5**	**0.55**	**0.48**	**0.58**	**1.1**	**1.5**	**2.6**	Artif Bee Colony [8]
avg NEWUOA	**1.2**	**1.1**	**1**	8.4	12	8.6	8.2	8.1	8.1	8.0	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	7.1	8.7	9.2	869	*12e-1/1e5*	.	.	.	.	.	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	**3.0**	5.5	6.8	7.6	6.9	5.1	4.9	4.9	4.8	4.8	Adap DE (F-AUC) [10]
DE (Uniform)	5.9	8.6	11	10	9.2	6.8	6.4	6.4	6.4	6.4	DE (Uniform) [9]
IPOP-aCMA-ES	**2.1**	3.0	3.9	10	**1.4**	**1.1**	**1.1**	**1.1**	**1.1**	**1.1**	IPOP-aCMA-ES [16]
IPOP-CMA-ES	**2.4**	3.7	3.9	11	**1.4**	**1.1**	**1.1**	**1.1**	**1.1**	**1.1**	IPOP-CMA-ES [22]
CMA+DE-MOS	5.0	10	10	**2.7**	**0.43**	**0.49**	**0.55**	**0.70**	**1.0**	**1.1**	CMA+DE-MOS [18]
NBC-CMA	3.1	6.5	7.9	**5.0**	25	19	18	18	18	17	NBC-CMA [21]
POEMS	82	86	84	8.4	30	22	21	21	21	21	POEMS [17]
PM-AdapSS-DE	4.9	11	11	14	9.4	7.0	6.6	6.6	6.6	6.6	PM-AdapSS-DE [9, 10]
pPOEMS	81	78	81	17	17	13	13	14	14	15	pPOEMS [17, 20]
Basic RCGA	4.0	8.1	8.7	439	95	*97e-2/5e4*	.	.	.	.	Basic RCGA [24]
SPSA	13	19	25	*18e-1/1e5*	.	.	.	.	.	.	SPSA [13]

Table 69: Running time excess ERT/$\text{ERT}_{\text{best 2009}}$ on f_{21} in **5-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

21 Gallagher 101 peaks

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
ERT_{best}/D	0.20	0.20	8.2	231	335	338	341	344	346	351	ERT_{best}/D
(1,2)-CMA-ES	**1**	**1**	6.9	8.6	13	13	13	13	13	12	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	**1**	**1**	5.7	5.8	9.0	9.0	8.9	8.9	8.9	8.8	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	**1**	**1**	**2.4**	5.0	10	9.4	9.4	9.4	9.3	9.2	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	**1**	**1**	24	14	23	23	23	23	23	22	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	**1**	**1**	5.7	**2.9**	6.9	6.8	6.8	6.8	6.8	6.7	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	**1**	**1**	3.5	3.4	6.1	6.1	6.1	6.0	6.0	6.0	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	**1**	**1**	**1.2**	**1.7**	**3.1**	**3.1**	**3.1**	**3.1**	**3.1**	**3.1**	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	**1**	**1**	5.1	4.3	**5.3**	**5.3**	**5.3**	**5.2**	**5.2**	**5.2**	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	**1**	**1**	**2.7**	3.4	5.6	5.5	5.5	5.5	5.5	5.4	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	**1**	**1**	7.6	3.8	7.5	7.4	7.4	7.3	7.3	7.2	(1+2ms)-CMA-ES [2]
Artif Bee Colony	**1**	**1**	3.2	**1.8**	6.7	10	13	24	84	265	Artif Bee Colony [8]
avg NEWUOA	**1**	**1**	**1.7**	**2.5**	**3.6**	**3.5**	**3.5**	**3.5**	**3.5**	**3.5**	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	**1**	21	3.4	114	217	267	287	327	374	458	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	**1**	**1**	5.2	**1.7**	110	109	109	108	107	106	Adap DE (F-AUC) [10]
DE (Uniform)	**1**	**1**	4.5	33	76	76	75	75	74	74	DE (Uniform) [9]
IPOP-aCMA-ES	**1**	**1**	3.5	7.3	32	33	33	33	33	33	IPOP-aCMA-ES [16]
IPOP-CMA-ES	**1**	**1**	6.3	5.6	30	30	31	31	31	31	IPOP-CMA-ES [22]
CMA+DE-MOS	**1**	**1**	4.6	69	280	478	485	485	483	527	CMA+DE-MOS [18]
NBC-CMA	**1**	**1**	**2.5**	96	119	118	117	116	115	114	NBC-CMA [21]
POEMS	**1**	**1**	25	744	1429	1415	1405	1397	1389	1371	POEMS [17]
PM-AdapSS-DE	**1**	**1**	4.0	33	201	199	198	196	195	192	PM-AdapSS-DE [9, 10]
pPOEMS	**1**	**1**	28	11	214	238	243	254	263	283	pPOEMS [17, 20]
Basic RCGA	**1**	**1**	**2.5**	84	105	129	129	134	135	140	Basic RCGA [24]
SPSA	**1**	34	34	299	1985	1967	1958	1997	4056	3995	SPSA [13]

Table 70: Running time excess ERT/$\text{ERT}_{\text{best 2009}}$ on f_{22} in **5-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

22 Gallagher 21 peaks

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
ERT_{best}/D	0.20	0.20	14	77	188	196	202	205	208	214	ERT_{best}/D
(1,2)-CMA-ES	**1**	**1**	18	31	31	30	30	29	29	29	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	**1**	**1**	10	11	20	19	19	19	18	18	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	**1**	**1**	15	21	51	49	48	47	47	46	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	**1**	**1**	23	32	49	47	46	46	45	44	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	**1**	**1**	6.9	13	16	16	15	15	15	15	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	**1**	**1**	12	10	12	12	12	12	12	11	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	**1**	**1**	10	12	15	15	14	14	14	14	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	**1**	**1**	16	18	12	11	11	11	11	11	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	**1**	**1**	3.7	8.0	**8.5**	**8.2**	**8.0**	**8.0**	**7.9**	**7.8**	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	**1**	**1**	**3.1**	**6.5**	**4.9**	**4.7**	**4.6**	**4.6**	**4.6**	**4.5**	(1+2ms)-CMA-ES [2]
Artif Bee Colony	**1**	**1**	5.1	7.6	35	237	374	1160	3311	6900	Artif Bee Colony [8]
avg NEWUOA	**1**	**1**	**3.4**	**2.6**	**2.3**	**2.3**	**2.3**	**2.3**	**2.4**	**2.4**	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	**1**	27	58	336	1483	1421	1384	1364	1933	1885	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	**1**	**1**	4.8	203	803	768	747	734	724	706	Adap DE (F-AUC) [10]
DE (Uniform)	**1**	**1**	6.6	203	469	450	437	430	424	414	DE (Uniform) [9]
IPOP-aCMA-ES	**1**	**1**	8.8	21	65	276	270	265	262	257	IPOP-aCMA-ES [16]
IPOP-CMA-ES	**1**	**1**	12	48	166	165	161	159	158	155	IPOP-CMA-ES [22]
CMA+DE-MOS	**1**	**1**	3.7	24	299	483	557	551	549	541	CMA+DE-MOS [18]
NBC-CMA	**1**	**1**	**3.0**	264	289	360	350	343	339	331	NBC-CMA [21]
POEMS	**1**	**1**	1137	2347	2593	2485	2417	2377	2348	2292	POEMS [17]
PM-AdapSS-DE	**1**	**1**	4.1	**4.6**	469	449	437	430	424	414	PM-AdapSS-DE [9, 10]
pPOEMS	**1**	**1**	29	24	268	276	284	305	326	362	pPOEMS [17, 20]
Basic RCGA	**1**	**1**	6.2	154	365	857	1697	1716	1706	3410	Basic RCGA [24]
SPSA	**1**	42	676	1318	7823	*69e-2/1e5*	.	.	.	.	SPSA [13]

Table 71: Running time excess $\mathrm{ERT}/\mathrm{ERT}_{\text{best 2009}}$ on f_{23} in **5-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

23 Katsuuras

Δftarget $\mathrm{ERT}_{\text{best}}$/D	1e+03 0.20	1e+02 0.20	1e+01 0.60	1e+00 104	1e-01 2850	1e-02 5578	1e-03 6331	1e-04 6479	1e-05 6606	1e-07 6851	Δftarget $\mathrm{ERT}_{\text{best}}$/D
(1,2)-CMA-ES	**1**	**1**	**2.8**	101	*97e-2/1e4*	.	.	.	.	.	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	**1**	**1**	15	37	16	13	23	23	22	21	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	**1**	**1**	6.4	23	9.5	26	*18e-2/1e4*	.	.	.	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	**1**	**1**	3.1	105	*98e-2/1e4*	.	.	.	.	.	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	**1**	**1**	5.7	28	7.0	12	11	22	22	21	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	**1**	**1**	3.8	12	4.2	*87e-3/1e4*	.	.	.	.	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	**1**	**1**	**2.2**	8.9	24	25	*20e-2/1e4*	.	.	.	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	**1**	**1**	**3.0**	23	51	*23e-2/1e4*	.	.	.	.	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	**1**	**1**	5.0	**5.4**	5.5	12	*10e-2/1e4*	.	.	.	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	**1**	**1**	4.7	**1.3**	9.3	*12e-2/1e4*	.	.	.	.	(1+2ms)-CMA-ES [2]
Artif Bee Colony	**1**	**1**	**2.2**	19	*37e-2/1e5*	.	.	.	.	.	Artif Bee Colony [8]
avg NEWUOA	**1**	**1**	6.0	**2.5**	14	*15e-2/9e3*	.	.	.	.	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	**1**	8.1	15	33	*55e-2/1e5*	.	.	.	.	.	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	**1**	**1**	**2.4**	9.3	**2.3**	**2.5**	**3.4**	**4.4**	**5.3**	**6.9**	Adap DE (F-AUC) [10]
DE (Uniform)	**1**	**1**	**2.0**	11	**2.5**	**2.7**	**3.6**	**4.6**	**5.5**	**7.2**	DE (Uniform) [9]
IPOP-aCMA-ES	**1**	**1**	**1.6**	20	76	39	34	33	33	32	IPOP-aCMA-ES [16]
IPOP-CMA-ES	**1**	**1**	**2.2**	26	33	17	15	15	14	14	IPOP-CMA-ES [22]
CMA+DE-MOS	**1**	**1**	**2.2**	16	**4.1**	**3.5**	**3.8**	**3.7**	**4.0**	**3.9**	CMA+DE-MOS [18]
NBC-CMA	**1**	**1**	**1.4**	42	299	153	135	132	129	124	NBC-CMA [21]
POEMS	**1**	**1**	12	21	41	63	57	56	55	54	POEMS [17]
PM-AdapSS-DE	**1**	**1**	**1.8**	8.9	12	15	14	15	21	27	PM-AdapSS-DE [9, 10]
pPOEMS	**1**	**1**	3.4	71	29	43	42	44	47	53	pPOEMS [17, 20]
Basic RCGA	**1**	**1**	**2.2**	37	119	*53e-2/5e4*	.	.	.	.	Basic RCGA [24]
SPSA	**1**	105	309	1779	*11e-1/1e5*	.	.	.	.	.	SPSA [13]

Table 72: Running time excess ERT/$\text{ERT}_{\text{best 2009}}$ on f_{24} in **5-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

24 Lunacek bi-Rastrigin

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
ERT_{best}/D	0.20	0.20	324	43284	1.27e6	1.92e6	1.92e6	1.92e6	2.57e6	2.57e6	ERT_{best}/D
(1,2)-CMA-ES	**1**	11	40	*87e-1/1e4*	.	.	.	.	.	.	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	**1**	7.9	8.3	*50e-1/1e4*	.	.	.	.	.	.	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	**1**	7.5	6.0	*54e-1/1e4*	.	.	.	.	.	.	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	**1**	15	49	*10e+0/1e4*	.	.	.	.	.	.	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	**1**	**4.9**	5.3	*41e-1/1e4*	.	.	.	.	.	.	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	**1**	10	4.4	*33e-1/1e4*	.	.	.	.	.	.	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	**1**	6.3	6.0	**3.3**	*31e-1/1e4*	.	.	.	.	.	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	**1**	**3.9**	7.0	*58e-1/1e4*	.	.	.	.	.	.	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	**1**	9.3	6.2	*42e-1/1e4*	.	.	.	.	.	.	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	**1**	5.6	4.7	3.3	*50e-1/1e4*	.	.	.	.	.	(1+2ms)-CMA-ES [2]
Artif Bee Colony	**1**	6.1	13	*42e-1/1e5*	.	.	.	.	.	.	Artif Bee Colony [8]
avg NEWUOA	**1**	14	**2.0**	**2.2**	*30e-1/7e3*	.	.	.	.	.	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	31	57	30	*23e-1/1e5*	.	.	.	.	.	.	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	**1**	5.7	4.1	3.7	**0.13**	**0.15**	**0.15**	**0.15**	**0.11**	**0.11**	Adap DE (F-AUC) [10]
DE (Uniform)	**1**	**3.9**	4.3	3.7	**0.17**	**0.15**	**0.15**	**0.15**	**0.11**	**0.11**	DE (Uniform) [9]
IPOP-aCMA-ES	**1**	6.5	**2.6**	41	*50e-1/3e5*	.	.	.	.	.	IPOP-aCMA-ES [16]
IPOP-CMA-ES	**1**	6.3	**2.9**	18	**1.4**	**0.94**	**0.94**	**0.94**	**0.70**	**0.70**	IPOP-CMA-ES [22]
CMA+DE-MOS	**1**	5.7	**2.2**	**2.8**	**0.52**	**1.2**	**1.2**	**1.2**	**0.87**	**0.87**	CMA+DE-MOS [18]
NBC-CMA	**1**	5.5	15	9.4	*56e-1/6e4*	.	.	.	.	.	NBC-CMA [21]
POEMS	**1**	505	72	*62e-1/3e5*	.	.	.	.	.	.	POEMS [17]
PM-AdapSS-DE	**1**	6.8	5.9	6.8	**0.24**	**0.36**	**0.36**	**0.36**	**0.27**	**0.27**	PM-AdapSS-DE [9, 10]
pPOEMS	**1**	157	39	7.2	*85e-2/3e5*	.	.	.	.	.	pPOEMS [17, 20]
Basic RCGA	**1**	8.1	3.5	8.2	*55e-1/5e4*	.	.	.	.	.	Basic RCGA [24]
SPSA	76	3.02e5	4351	*74e+0/1e5*	.	.	.	.	.	.	SPSA [13]

Table 73: Running time excess $\mathrm{ERT}/\mathrm{ERT}_{\text{best 2009}}$ on f_1 in **10-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

1 Sphere

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
$\mathrm{ERT}_{\text{best}}$/D	0.10	0.10	2.2	2.3	2.3	2.3	2.3	2.3	2.3	2.3	$\mathrm{ERT}_{\text{best}}$/D
(1,2)-CMA-ES	**1**	23	13	21	31	40	48	58	67	85	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	**1**	13	6.5	12	17	23	28	34	40	52	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	**1**	8.3	5.9	11	15	20	25	31	36	45	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	**1**	20	10	19	28	35	45	53	62	81	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	**1**	11	4.7	10	14	20	25	30	36	46	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	**1**	**2.7**	4.1	8.2	13	17	21	26	30	39	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	**1**	5.5	**3.6**	**6.7**	**10**	**13**	**16**	**20**	**23**	**29**	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	**1**	14	4.3	8.3	13	16	21	25	29	38	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	**1**	11	4.1	8.1	12	15	19	23	27	34	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	**1**	9.3	**3.7**	**6.8**	**10**	**13**	**17**	**20**	**24**	**31**	(1+2ms)-CMA-ES [2]
Artif Bee Colony	**1**	4.9	24	55	86	114	165	203	238	306	Artif Bee Colony [8]
avg NEWUOA	**1**	27	**1.7**	**1.7**	**1.7**	**1.7**	**1.7**	**1.7**	**1.7**	**1.7**	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	7.7	85	11	19	26	34	42	49	57	72	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	**1**	4.5	37	91	137	189	239	290	343	443	Adap DE (F-AUC) [10]
DE (Uniform)	**1**	4.9	48	121	198	269	344	423	496	649	DE (Uniform) [9]
IPOP-aCMA-ES	**1**	9.2	6.2	13	19	26	32	39	44	58	IPOP-aCMA-ES [16]
IPOP-CMA-ES	**1**	7.7	5.0	11	18	24	30	37	43	56	IPOP-CMA-ES [22]
CMA+DE-MOS	**1**	5.9	19	57	71	94	124	140	166	214	CMA+DE-MOS [18]
NBC-CMA	**1**	5.8	16	25	34	45	54	63	73	93	NBC-CMA [21]
POEMS	**1**	1684	130	244	608	1045	1469	1958	2403	3321	POEMS [17]
PM-AdapSS-DE	**1**	**4.3**	41	95	158	218	275	338	399	518	PM-AdapSS-DE [9, 10]
pPOEMS	**1**	527	125	252	1035	3154	5744	8009	10514	16455	pPOEMS [17, 20]
Basic RCGA	**1**	**4.0**	33	105	207	345	1034	1984	2693	3761	Basic RCGA [24]
SPSA	8.4	104	7.7	11	13	16	19	22	25	31	SPSA [13]

Table 74: Running time excess ERT/ERT$_{\text{best 2009}}$ on f_2 in **10-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

2 Ellipsoid separable

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
ERT$_{\text{best}}$/D	15	18	19	19	19	19	19	19	19	20	ERT$_{\text{best}}$/D
(1,2)-CMA-ES	56	75	90	93	99	101	103	104	106	108	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	31	35	46	49	51	51	52	52	53	54	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	27	30	38	42	43	44	44	45	46	47	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	72	83	101	107	112	113	116	118	119	123	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	18	23	31	35	36	36	37	37	38	39	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	11	19	27	30	32	32	33	33	34	35	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	10	15	21	23	23	24	24	25	25	26	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	14	19	26	29	31	31	32	33	33	34	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	8.6	12	17	21	**21**	**22**	**22**	**23**	**23**	**24**	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	**7.5**	**10**	**13**	**16**	**18**	**18**	**19**	**19**	**20**	**20**	(1+2ms)-CMA-ES [2]
Artif Bee Colony	**6.5**	**7.2**	**11**	**15**	22	28	38	48	56	68	Artif Bee Colony [8]
avg NEWUOA	**2.5**	**6.1**	16	39	67	90	124	157	184	250	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	46	52	61	66	67	68	70	70	71	73	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	20	22	29	34	40	46	52	58	64	75	Adap DE (F-AUC) [10]
DE (Uniform)	26	30	39	47	55	64	74	82	91	109	DE (Uniform) [9]
IPOP-aCMA-ES	7.9	11	**14**	**16**	**18**	**19**	**20**	**20**	**21**	**23**	IPOP-aCMA-ES [16]
IPOP-CMA-ES	12	15	21	25	26	26	27	28	28	30	IPOP-CMA-ES [22]
CMA+DE-MOS	20	22	30	37	43	48	53	57	62	71	CMA+DE-MOS [18]
NBC-CMA	14	21	32	37	41	43	45	46	47	49	NBC-CMA [21]
POEMS	134	160	214	267	327	369	427	478	533	641	POEMS [17]
PM-AdapSS-DE	23	25	32	39	46	53	59	67	74	87	PM-AdapSS-DE [9, 10]
pPOEMS	270	440	612	1018	1277	1785	2032	2336	2621	3285	pPOEMS [17, 20]
Basic RCGA	37	55	95	147	233	320	394	442	678	1482	Basic RCGA [24]
SPSA	7996	*69e+1/1e5*	.	.	.	.	.	.	.	.	SPSA [13]

Table 75: Running time excess $\mathrm{ERT}/\mathrm{ERT}_{\text{best 2009}}$ on f_3 in **10-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

3 Rastrigin separable

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
$\mathrm{ERT}_{\text{best}}$/D	0.10	6.9	174	360	361	364	364	364	365	365	$\mathrm{ERT}_{\text{best}}$/D
(1,2)-CMA-ES	4.4	61	*30e+0/1e4*	.	.	.	.	.	.	.	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	**1.6**	5.3	274	*14e+0/1e4*	.	.	.	.	.	.	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	**1.3**	6.2	390	*17e+0/1e4*	.	.	.	.	.	.	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	4.0	83	398	*38e+0/1e4*	.	.	.	.	.	.	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	7.9	7.2	*15e+0/1e4*	.	.	.	.	.	.	.	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	**2.2**	3.5	91	*11e+0/1e4*	.	.	.	.	.	.	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	3.3	3.5	76	*99e-1/1e4*	.	.	.	.	.	.	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	3.1	6.0	376	*18e+0/1e4*	.	.	.	.	.	.	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	4.1	14	838	*18e+0/1e4*	.	.	.	.	.	.	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	7.3	**2.4**	835	*20e+0/1e4*	.	.	.	.	.	.	(1+2ms)-CMA-ES [2]
Artif Bee Colony	**2.3**	6.0	**1.6**	**2.2**	**2.5**	**2.8**	**3.1**	**3.4**	**3.8**	**4.5**	Artif Bee Colony [8]
avg NEWUOA	11	16	*21e+0/7e3*	.	.	.	.	.	.	.	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	51	5.0	78	3903	3893	3864	3859	3859	3857	*50e-1/1e5*	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	**2.1**	15	200	1212	3965	3936	3930	3929	3926	3921	Adap DE (F-AUC) [10]
DE (Uniform)	**1.7**	20	211	4009	*30e-1/1e5*	.	.	.	.	.	DE (Uniform) [9]
IPOP-aCMA-ES	3.5	**2.9**	5.6	643	2678	2659	2656	2655	2653	2651	IPOP-aCMA-ES [16]
IPOP-CMA-ES	**2.6**	**3.2**	**2.7**	1658	5796	5752	5744	5742	5737	5729	IPOP-CMA-ES [22]
CMA+DE-MOS	**2.0**	8.1	**2.1**	**3.0**	**3.7**	**4.0**	**4.4**	**4.7**	**4.9**	**5.6**	CMA+DE-MOS [18]
NBC-CMA	**1.7**	6.0	8.2	1213	*40e-1/3e4*	.	.	.	.	.	NBC-CMA [21]
POEMS	678	43	6.8	**28**	**54**	**56**	**58**	**62**	**64**	**70**	POEMS [17]
PM-AdapSS-DE	**2.2**	18	93	508	646	1876	3944	*10e-1/1e5*	.	.	PM-AdapSS-DE [9, 10]
pPOEMS	**2.4**	45	8.2	54	134	140	154	165	186	227	pPOEMS [17, 20]
Basic RCGA	**2.4**	12	8.2	133	255	330	333	335	336	339	Basic RCGA [24]
SPSA	6.67e5	12992	*87e+0/1e5*	.	.	.	.	.	.	.	SPSA [13]

Table 76: Running time excess ERT/ERT$_{\text{best 2009}}$ on f_4 in **10-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

4 Skew Rastrigin-Bueche separ

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
ERT$_{\text{best}}$/D	0.10	10	223	363	366	370	371	374	374	2877	ERT$_{\text{best}}$/D
(1,2)-CMA-ES	3.4	67	*41e+0/1e4*	.	.	.	.	.	.	.	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	6.4	6.2	306	*18e+0/1e4*	.	.	.	.	.	.	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	7.8	8.7	209	*18e+0/1e4*	.	.	.	.	.	.	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	13	145	*51e+0/1e4*	.	.	.	.	.	.	.	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	5.6	6.2	*22e+0/1e4*	.	.	.	.	.	.	.	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	5.7	**5.4**	*17e+0/1e4*	.	.	.	.	.	.	.	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	8.1	5.4	311	*15e+0/1e4*	.	.	.	.	.	.	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	3.0	23	*20e+0/1e4*	.	.	.	.	.	.	.	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	5.7	19	317	*27e+0/1e4*	.	.	.	.	.	.	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	4.1	21	*26e+0/1e4*	.	.	.	.	.	.	.	(1+2ms)-CMA-ES [2]
Artif Bee Colony	3.1	5.4	**1.3**	**3.2**	**4.4**	**5.1**	**5.7**	**6.3**	**6.7**	**0.99**	Artif Bee Colony [8]
avg NEWUOA	13	42	*27e+0/1e4*	.	.	.	.	.	.	.	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	93	5.5	362	*90e-1/1e5*	.	.	.	.	.	.	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	4.1	20	92	*60e-1/1e5*	.	.	.	.	.	.	Adap DE (F-AUC) [10]
DE (Uniform)	3.1	26	111	*50e-1/1e5*	.	.	.	.	.	.	DE (Uniform) [9]
IPOP-aCMA-ES	6.3	**3.1**	7.6	*60e-1/1e5*	.	.	.	.	.	.	IPOP-aCMA-ES [16]
IPOP-CMA-ES	**2.9**	**3.4**	7.5	*60e-1/2e5*	.	.	.	.	.	.	IPOP-CMA-ES [22]
CMA+DE-MOS	**2.2**	8.5	**1.9**	**6.8**	**8.2**	**8.6**	**9.1**	**9.4**	**10**	**1.4**	CMA+DE-MOS [18]
NBC-CMA	**2.6**	6.0	8.1	*60e-1/3e4*	.	.	.	.	.	.	NBC-CMA [21]
POEMS	1209	34	**6.6**	**40**	**114**	**116**	**120**	**120**	**123**	**17**	POEMS [17]
PM-AdapSS-DE	3.9	22	92	*60e-1/1e5*	.	.	.	.	.	.	PM-AdapSS-DE [9, 10]
pPOEMS	**2.3**	37	10	68	285	298	316	332	348	51	pPOEMS [17, 20]
Basic RCGA	**2.3**	19	107	*79e-1/5e4*	.	.	.	.	.	.	Basic RCGA [24]
SPSA	185	8979	*99e+0/1e5*	.	.	.	.	.	.	.	SPSA [13]

Table 77: Running time excess $\mathrm{ERT}/\mathrm{ERT}_{\text{best 2009}}$ on f_5 in **10-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

5 Linear slope

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
$\mathrm{ERT}_{\text{best}}$/D	0.10	1.6	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	$\mathrm{ERT}_{\text{best}}$/D
(1,2)-CMA-ES	**1**	**2.1**	5.7	6.9	7.1	7.1	7.1	7.1	7.1	7.1	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	**1**	**1.0**	**2.9**	3.4	3.7	3.8	3.8	3.8	3.8	3.8	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	**1**	**0.97**	3.5	4.0	4.1	4.1	4.1	4.1	4.1	4.1	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	**1**	**1.5**	6.3	8.2	8.3	8.3	8.3	8.3	8.3	8.3	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	**1**	**1.3**	4.3	5.4	5.6	5.6	5.6	5.6	5.6	5.6	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	**1**	**1.3**	4.2	5.2	5.3	5.3	5.3	5.3	5.3	5.3	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	**1**	**1.0**	3.4	4.1	4.1	4.2	4.2	4.2	4.2	4.2	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	**1**	**1.3**	3.0	4.1	4.1	4.2	4.2	4.2	4.2	4.2	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	**1**	**0.75**	**2.8**	**3.2**	**3.3**	**3.3**	**3.4**	**3.4**	**3.4**	**3.4**	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	**1**	**0.80**	**2.1**	**2.7**	**3.0**	**3.0**	**3.0**	**3.0**	**3.0**	**3.0**	(1+2ms)-CMA-ES [2]
Artif Bee Colony	**1**	8.8	51	71	75	75	75	75	75	75	Artif Bee Colony [8]
avg NEWUOA	**1**	**1.9**	**2.0**	**2.3**	**2.3**	**2.3**	**2.3**	**2.3**	**2.3**	**2.3**	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	**1**	3.2	5.4	6.1	6.1	6.1	6.1	6.1	6.1	6.1	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	**1**	4.7	31	39	44	44	44	44	44	44	Adap DE (F-AUC) [10]
DE (Uniform)	**1**	6.7	43	53	56	58	58	58	58	58	DE (Uniform) [9]
IPOP-aCMA-ES	**1**	**2.0**	5.2	6.7	6.8	6.8	6.8	6.8	6.8	6.8	IPOP-aCMA-ES [16]
IPOP-CMA-ES	**1**	**2.0**	4.9	5.9	6.2	6.2	6.2	6.2	6.2	6.2	IPOP-CMA-ES [22]
CMA+DE-MOS	**1**	6.2	34	54	54	54	54	54	54	54	CMA+DE-MOS [18]
NBC-CMA	**1**	8.2	36	43	43	43	43	43	43	43	NBC-CMA [21]
POEMS	**1**	135	198	235	263	274	277	277	277	277	POEMS [17]
PM-AdapSS-DE	**1**	4.8	39	52	54	54	54	54	54	54	PM-AdapSS-DE [9, 10]
pPOEMS	**1**	127	196	232	253	272	275	276	276	276	pPOEMS [17, 20]
Basic RCGA	**1**	28	391	791	1242	1958	3124	4360	5138	73940	Basic RCGA [24]
SPSA	**1**	**2.3**	6.2	8.2	8.6	8.7	8.7	8.7	8.7	8.7	SPSA [13]

Table 78: Running time excess $\mathrm{ERT}/\mathrm{ERT}_{\text{best 2009}}$ on f_6 in **10-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

6 Attractive sector

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
$\mathrm{ERT}_{\text{best}}$/D	2.8	10	41	62	83	104	129	157	184	237	$\mathrm{ERT}_{\text{best}}$/D
(1,2)-CMA-ES	4.0	8.8	7.1	9.2	12	19	21	25	35	90	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	3.1	4.4	**2.4**	**2.2**	**2.3**	**2.4**	**2.3**	**2.4**	**2.4**	**2.4**	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	4.1	3.9	**1.9**	**1.9**	**2.1**	**2.1**	**2.1**	**2.1**	**2.2**	**2.5**	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	8.4	13	10	17	35	44	55	77	77	597	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	**2.7**	3.1	**2.1**	**2.3**	**2.4**	**2.5**	**2.6**	**2.6**	**2.7**	**2.8**	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	**2.1**	**2.9**	**1.6**	**1.6**	**1.7**	**1.7**	**1.8**	**1.8**	**1.8**	**1.7**	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	**1.4**	**1.7**	**1.1**	**1.3**	**1.3**	**1.4**	**1.4**	**1.4**	**1.4**	**1.5**	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	**1.7**	**3.0**	**1.7**	**2.2**	**2.6**	**2.8**	**2.9**	3.7	4.2	4.6	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	**1.9**	**2.3**	**1.4**	5.9	26	78	246	938	*26e-4 /1e4*	.	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	**1.5**	**1.6**	**1.1**	**2.6**	14	75	155	937	*21e-4 /1e4*	.	(1+2ms)-CMA-ES [2]
Artif Bee Colony	10	4.7	12	232	598	2036	2247	2797	7830	6289	Artif Bee Colony [8]
avg NEWUOA	**1.5**	**1.6**	**0.97**	**0.99**	**1.0**	**1.0**	**1.1**	**1.1**	**1.1**	**1.1**	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	11	14	35	73	188	269	239	212	198	209	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	12	15	11	12	13	13	13	13	12	12	Adap DE (F-AUC) [10]
DE (Uniform)	12	23	15	16	17	17	17	16	16	16	DE (Uniform) [9]
IPOP-aCMA-ES	**2.1**	3.8	**1.8**	**1.9**	**1.8**	**1.8**	**1.7**	**1.7**	**1.6**	**1.6**	IPOP-aCMA-ES [16]
IPOP-CMA-ES	**2.5**	3.2	**1.9**	**1.9**	**1.9**	**1.9**	**1.8**	**1.8**	**1.7**	**1.7**	IPOP-CMA-ES [22]
CMA+DE-MOS	14	10	7.8	7.1	6.7	6.4	6.2	5.8	5.5	5.2	CMA+DE-MOS [18]
NBC-CMA	10	4.9	31	21	17	14	11	10	8.4	7.0	NBC-CMA [21]
POEMS	95	35	31	39	43	45	45	45	44	44	POEMS [17]
PM-AdapSS-DE	11	20	14	14	15	15	14	14	13	13	PM-AdapSS-DE [9, 10]
pPOEMS	99	35	40	71	128	138	149	151	156	168	pPOEMS [17, 20]
Basic RCGA	38	14	39	83	136	313	407	941	*56e-5 /5e4*	.	Basic RCGA [24]
SPSA	1269	67510	35633	*22e+1 /1e5*	.	.	.	.	.	.	SPSA [13]

Table 79: Running time excess $\mathrm{ERT}/\mathrm{ERT}_{\text{best 2009}}$ on f_7 in **10-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

7 Step-ellipsoid

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
$\mathrm{ERT}_{\text{best}}/\mathrm{D}$	0.10	3.3	17	161	420	510	514	514	514	539	$\mathrm{ERT}_{\text{best}}/\mathrm{D}$
(1,2)-CMA-ES	5.9	16	56	*35e-1/1e4*	.	.	.	.	.	.	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	4.5	5.0	12	47	164	*73e-2/1e4*	.	.	.	.	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	**2.3**	6.2	8.8	47	*59e-2/1e4*	.	.	.	.	.	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	4.7	16	102	*40e-1/1e4*	.	.	.	.	.	.	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	3.9	3.6	5.1	53	*65e-2/1e4*	.	.	.	.	.	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	8.6	3.1	3.6	25	337	*56e-2/1e4*	.	.	.	.	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	5.7	3.2	4.9	21	161	*69e-2/1e4*	.	.	.	.	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	5.3	**2.2**	11	75	339	*10e-1/1e4*	.	.	.	.	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	4.0	**2.7**	18	6.4	6.5	10	12	12	12	12	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	3.1	**2.0**	14	5.6	7.4	13	13	13	13	13	(1+2ms)-CMA-ES [2]
Artif Bee Colony	**2.7**	8.2	27	512	1627	*95e-2/1e5*	.	.	.	.	Artif Bee Colony [8]
avg NEWUOA	3.0	**1.4**	16	38	*73e-2/1e4*	.	.	.	.	.	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	64	11	10	2491	*31e-1/1e5*	.	.	.	.	.	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	**2.3**	11	10	**2.1**	**1.2**	**1.3**	**1.4**	**1.4**	**1.4**	**1.4**	Adap DE (F-AUC) [10]
DE (Uniform)	**2.9**	14	12	**2.8**	**1.7**	**1.9**	**1.9**	**1.9**	**1.9**	**2.0**	DE (Uniform) [9]
IPOP-aCMA-ES	7.2	3.3	**2.7**	**1.2**	**0.75**	**0.77**	**0.77**	**0.77**	**0.77**	**0.75**	IPOP-aCMA-ES [16]
IPOP-CMA-ES	4.7	**2.7**	**2.6**	**1.9**	**1.5**	**1.4**	**1.4**	**1.4**	**1.4**	**1.4**	IPOP-CMA-ES [22]
CMA+DE-MOS	**2.6**	7.7	7.8	**3.0**	**2.3**	**2.1**	**2.1**	**2.1**	**2.1**	**2.0**	CMA+DE-MOS [18]
NBC-CMA	**2.6**	5.0	**3.4**	**1.5**	4.0	13	15	15	15	16	NBC-CMA [21]
POEMS	791	79	35	12	147	123	123	123	123	117	POEMS [17]
PM-AdapSS-DE	**2.4**	12	10	**2.4**	**1.4**	**1.5**	**1.5**	**1.5**	**1.5**	**1.5**	PM-AdapSS-DE [9, 10]
pPOEMS	**2.1**	83	40	35	29	43	46	46	46	44	pPOEMS [17, 20]
Basic RCGA	3.1	8.3	82	81	298	*12e-2/5e4*	.	.	.	.	Basic RCGA [24]
SPSA	390	64	81647	*28e+0/1e5*	.	.	.	.	.	.	SPSA [13]

Table 80: Running time excess ERT/ERT$_{\text{best 2009}}$ on f_8 in **10-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

8 Rosenbrock original

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
ERT$_{\text{best}}$/D	4.2	13	33	92	111	122	127	129	132	134	ERT$_{\text{best}}$/D
(1,2)-CMA-ES	13	14	10	20	19	19	19	19	19	19	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	4.8	3.0	**2.3**	7.6	7.7	7.7	7.7	7.7	7.7	7.8	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	3.9	4.8	**2.9**	6.8	6.7	6.6	6.6	6.7	6.7	6.8	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	8.9	12	8.4	24	23	22	22	22	22	22	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	4.4	4.8	**3.0**	7.0	6.8	6.7	6.6	6.7	6.7	6.8	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	3.1	**2.3**	**1.6**	6.1	5.9	5.8	5.8	5.8	5.8	5.9	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	**2.9**	**1.7**	**1.2**	5.3	5.1	4.9	4.9	4.9	4.9	4.9	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	3.3	3.1	3.3	5.0	5.0	4.9	5.0	5.0	5.0	5.1	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	**2.3**	**2.8**	**2.2**	**3.5**	**3.5**	**3.5**	**3.5**	**3.6**	**3.6**	**3.8**	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	**2.5**	**2.1**	**1.9**	**3.5**	**3.4**	**3.3**	**3.3**	**3.4**	**3.4**	**3.6**	(1+2ms)-CMA-ES [2]
Artif Bee Colony	11	8.6	7.2	7.4	19	77	549	*40e-5/1e5*	.	.	Artif Bee Colony [8]
avg NEWUOA	**1.2**	**1.2**	**0.99**	**0.87**	**0.84**	**0.83**	**0.82**	**0.82**	**0.82**	**0.82**	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	8.9	7.2	5.2	8.4	8.3	8.3	8.4	8.7	9.1	10	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	23	16	14	14	15	15	15	16	16	18	Adap DE (F-AUC) [10]
DE (Uniform)	33	24	20	20	21	21	22	23	23	26	DE (Uniform) [9]
IPOP-aCMA-ES	3.9	3.2	**2.6**	4.4	4.4	4.3	4.3	4.4	4.4	4.6	IPOP-aCMA-ES [16]
IPOP-CMA-ES	4.0	3.1	**2.3**	3.7	3.9	3.9	4.0	4.1	4.2	4.3	IPOP-CMA-ES [22]
CMA+DE-MOS	16	10	6.7	12	12	12	12	12	13	13	CMA+DE-MOS [18]
NBC-CMA	9.4	4.3	3.1	6.4	7.1	7.5	7.6	7.8	7.9	8.1	NBC-CMA [21]
POEMS	74	57	64	706	1065	1469	2026	2936	*40e-6/3e5*	.	POEMS [17]
PM-AdapSS-DE	25	19	16	20	21	22	22	23	23	25	PM-AdapSS-DE [9, 10]
pPOEMS	75	53	162	200	199	198	207	233	270	378	pPOEMS [17, 20]
Basic RCGA	17	22	102	1998	6723	*56e-1/5e4*	.	.	.	.	Basic RCGA [24]
SPSA	457	1339	8736	*13e+0/1e5*	.	.	.	.	.	.	SPSA [13]

Table 81: Running time excess ERT/$\text{ERT}_{\text{best 2009}}$ on f_9 in **10-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

9 Rosenbrock rotated

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
ERT_{best}/D	0.10	0.10	20	65	86	99	107	111	114	119	ERT_{best}/D
(1,2)-CMA-ES	444	824	7.0	27	24	22	21	21	21	21	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	191	326	5.0	11	10	9.1	8.8	8.7	8.7	8.7	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	282	609	5.0	9.3	8.5	7.9	7.7	7.6	7.6	7.5	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	454	2209	15	30	27	25	24	23	23	23	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	145	657	5.2	9.2	8.3	7.7	7.5	7.3	7.3	7.3	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	139	717	5.1	8.0	7.2	6.7	6.5	6.4	6.4	6.3	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	**91**	**309**	**3.1**	6.4	5.7	5.3	5.1	5.0	5.0	5.0	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	144	487	3.6	6.2	5.8	5.4	5.3	5.3	5.3	5.3	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	105	312	**2.7**	7.2	6.3	5.7	5.5	5.4	5.5	5.5	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	**90**	**230**	3.8	**5.8**	**5.1**	**4.6**	**4.5**	**4.5**	**4.5**	**4.5**	(1+2ms)-CMA-ES [2]
Artif Bee Colony	489	1323	14	996	5680	*51e-2/1e5*	.	.	.	.	Artif Bee Colony [8]
avg NEWUOA	**69**	**148**	**1.3**	**1.8**	**1.5**	**1.4**	**1.3**	**1.3**	**1.2**	**1.2**	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	435	909	8.8	12	12	11	11	11	11	11	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	721	1759	22	21	20	19	19	19	20	21	Adap DE (F-AUC) [10]
DE (Uniform)	1175	2869	31	29	28	27	27	27	28	30	DE (Uniform) [9]
IPOP-aCMA-ES	134	322	4.1	**5.2**	**4.8**	**4.5**	**4.4**	**4.4**	**4.4**	**4.5**	IPOP-aCMA-ES [16]
IPOP-CMA-ES	127	328	3.2	6.2	5.8	5.4	5.3	5.2	5.3	5.4	IPOP-CMA-ES [22]
CMA+DE-MOS	659	785	6.4	12	12	11	11	11	11	11	CMA+DE-MOS [18]
NBC-CMA	293	672	5.6	11	11	11	11	11	11	11	NBC-CMA [21]
POEMS	3170	6784	113	1062	1614	2927	*70e-4/3e5*	.	.	.	POEMS [17]
PM-AdapSS-DE	894	2289	26	31	30	29	28	28	29	30	PM-AdapSS-DE [9, 10]
pPOEMS	2956	9087	326	268	313	426	560	694	853	1255	pPOEMS [17, 20]
Basic RCGA	350	811	54	*68e-1/5e4*	.	.	.	.	.	.	Basic RCGA [24]
SPSA	24148	4.43e5	10555	*43e+0/1e5*	.	.	.	.	.	.	SPSA [13]

Table 82: Running time excess $\mathrm{ERT}/\mathrm{ERT}_{\text{best 2009}}$ on f_{10} in **10-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

10 Ellipsoid

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
$\mathrm{ERT}_{\text{best}}/\mathrm{D}$	46	104	184	217	245	273	280	308	454	474	$\mathrm{ERT}_{\text{best}}/\mathrm{D}$
(1,2)-CMA-ES	24	14	9.4	8.8	8.1	7.5	7.4	6.8	4.7	4.6	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	10	6.6	4.7	4.3	3.9	3.6	3.6	3.3	**2.3**	**2.3**	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	7.7	5.8	4.3	3.8	3.4	3.1	3.1	**2.9**	**2.0**	**1.9**	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	18	13	8.5	8.7	8.1	7.5	7.5	6.9	4.8	4.8	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	5.5	3.8	**2.9**	**3.0**	**2.8**	**2.6**	**2.6**	**2.4**	**1.6**	**1.6**	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	4.2	3.3	**2.6**	**2.6**	**2.4**	**2.3**	**2.2**	**2.1**	**1.4**	**1.4**	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	3.4	**2.7**	**2.0**	**2.0**	**1.8**	**1.7**	**1.7**	**1.6**	**1.1**	**1.1**	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	5.4	3.4	**2.5**	**2.5**	**2.3**	**2.2**	**2.2**	**2.0**	**1.4**	**1.4**	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	**2.6**	**1.9**	**1.8**	**1.8**	**1.7**	**1.6**	**1.6**	**1.4**	**1.0**	**1.0**	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	**2.1**	**1.6**	**1.4**	**1.4**	**1.4**	**1.3**	**1.3**	**1.2**	**0.82**	**0.82**	(1+2ms)-CMA-ES [2]
Artif Bee Colony	3835	*11e+2/1e5*	.	.	.	.	.	.	.	.	Artif Bee Colony [8]
avg NEWUOA	**1.3**	**1.3**	**1.9**	3.5	5.4	6.6	9.0	10	8.1	10	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	17	10	6.2	5.6	5.2	4.7	4.7	4.3	**3.0**	**2.9**	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	6.2	4.0	**2.9**	3.0	3.1	3.3	3.6	3.7	**2.7**	3.1	Adap DE (F-AUC) [10]
DE (Uniform)	7.8	5.2	3.9	4.1	4.4	4.6	5.1	5.2	3.9	4.5	DE (Uniform) [9]
IPOP-aCMA-ES	**2.4**	**1.8**	**1.5**	**1.4**	**1.4**	**1.3**	**1.3**	**1.3**	**0.89**	**0.91**	IPOP-aCMA-ES [16]
IPOP-CMA-ES	4.0	**2.6**	**2.0**	**2.0**	**2.0**	**1.9**	**1.9**	**1.8**	**1.2**	**1.2**	IPOP-CMA-ES [22]
CMA+DE-MOS	8.9	6.0	4.5	4.4	4.3	4.1	4.2	3.9	**2.7**	**2.8**	CMA+DE-MOS [18]
NBC-CMA	4.9	3.7	3.1	3.2	3.2	3.1	3.2	3.0	**2.1**	**2.1**	NBC-CMA [21]
POEMS	353	1546	24342	*33e+0/3e5*	.	.	.	.	.	.	POEMS [17]
PM-AdapSS-DE	7.1	4.5	3.4	3.4	3.6	3.8	4.1	4.2	3.2	3.6	PM-AdapSS-DE [9, 10]
pPOEMS	195	363	1202	6015	8674	*27e-1/3e5*	.	.	.	.	pPOEMS [17, 20]
Basic RCGA	1504	*99e+1/5e4*	.	.	.	.	.	.	.	.	Basic RCGA [24]
SPSA	15075	*19e+2/1e5*	.	.	.	.	.	.	.	.	SPSA [13]

Table 83: Running time excess ERT/$\text{ERT}_{\text{best 2009}}$ on f_{11} in **10-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

11 Discus

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
ERT_{best}/D	2.0	2.3	27	104	260	295	334	375	409	484	ERT_{best}/D
(1,2)-CMA-ES	55	346	38	12	5.3	5.1	4.8	4.4	4.1	3.6	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	55	228	25	7.4	3.3	3.0	**2.8**	**2.6**	**2.4**	**2.1**	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	53	211	23	6.5	**2.8**	**2.6**	**2.4**	**2.2**	**2.1**	**1.8**	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	117	396	44	13	5.7	5.5	5.2	4.8	4.6	4.0	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	40	157	19	5.5	**2.4**	**2.3**	**2.2**	**2.0**	**1.9**	**1.7**	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	51	179	20	5.8	**2.5**	**2.3**	**2.1**	**2.0**	**1.8**	**1.6**	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	33	118	13	3.8	**1.7**	**1.6**	**1.4**	**1.3**	**1.2**	**1.1**	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	28	143	15	4.5	**2.0**	**1.8**	**1.7**	**1.6**	**1.5**	**1.3**	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	**2.3**	34	10	4.2	**2.2**	**2.1**	**2.0**	**1.8**	**1.7**	**1.5**	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	**2.2**	36	**9.2**	**3.7**	**1.8**	**1.8**	**1.7**	**1.6**	**1.5**	**1.3**	(1+2ms)-CMA-ES [2]
Artif Bee Colony	3.3	30	*18e+0/1e5*	.	.	.	.	.	.	.	Artif Bee Colony [8]
avg NEWUOA	10	223	36	18	10	12	14	14	15	15	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	67	621	90	96	40	36	32	29	27	23	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	6.9	31	**9.2**	**3.6**	**1.9**	**2.1**	**2.2**	**2.3**	**2.4**	**2.5**	Adap DE (F-AUC) [10]
DE (Uniform)	7.8	52	11	4.6	**2.5**	**2.8**	3.0	3.2	3.3	3.5	DE (Uniform) [9]
IPOP-aCMA-ES	**3.2**	51	**7.0**	**2.0**	**0.89**	**0.84**	**0.80**	**0.75**	**0.73**	**0.68**	IPOP-aCMA-ES [16]
IPOP-CMA-ES	4.5	102	13	3.9	**1.7**	**1.6**	**1.5**	**1.4**	**1.3**	**1.2**	IPOP-CMA-ES [22]
CMA+DE-MOS	4.4	**30**	27	8.1	3.6	3.4	3.1	**2.9**	**2.8**	**2.5**	CMA+DE-MOS [18]
NBC-CMA	3.9	**30**	158	43	17	15	14	12	11	10	NBC-CMA [21]
POEMS	92	162	210	204	153	182	206	225	246	260	POEMS [17]
PM-AdapSS-DE	6.1	43	10	4.0	**2.1**	**2.3**	**2.5**	**2.6**	**2.7**	**2.8**	PM-AdapSS-DE [9, 10]
pPOEMS	82	212	206	169	117	150	166	182	196	213	pPOEMS [17, 20]
Basic RCGA	8.7	**21**	3809	*11e+0/5e4*	.	.	.	.	.	.	Basic RCGA [24]
SPSA	75	*34e+1/1e5*	.	.	.	.	.	.	.	.	SPSA [13]

Table 84: Running time excess ERT/$\text{ERT}_{\text{best 2009}}$ on f_{12} in **10-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

12 Bent cigar

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
ERT_{best}/D	21	28	52	90	124	139	157	197	366	515	ERT_{best}/D
(1,2)-CMA-ES	6.1	14	21	24	22	23	23	20	12	9.1	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	3.3	6.1	8.9	10	9.4	10	10	8.5	5.0	4.0	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	**2.8**	4.4	7.3	7.8	7.5	7.8	7.9	7.0	4.2	3.3	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	4.7	7.0	20	23	24	25	25	21	13	10	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	**2.8**	**2.6**	5.0	6.9	7.1	7.5	7.5	6.7	3.9	3.1	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	**2.4**	**2.2**	3.5	5.0	5.5	5.8	5.8	5.2	3.1	**2.5**	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	**1.8**	**2.2**	3.5	**4.8**	**5.1**	**5.4**	**5.4**	**4.8**	**2.9**	**2.3**	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	**2.2**	3.0	7.3	6.9	6.7	6.9	6.8	6.0	3.5	**2.8**	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	**2.0**	3.4	5.6	5.9	6.4	6.7	6.9	6.0	3.6	3.1	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	**1.6**	**1.9**	4.5	6.2	6.5	6.7	6.6	5.9	3.4	**2.8**	(1+2ms)-CMA-ES [2]
Artif Bee Colony	12	19	45	101	631	5044	9120	*41e-3/1e5*	.	.	Artif Bee Colony [8]
avg NEWUOA	**1.1**	**1.7**	4.7	8.0	10	12	12	12	6.9	10	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	5.0	7.9	21	26	27	29	28	25	16	16	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	26	25	16	12	13	14	15	14	8.9	7.6	Adap DE (F-AUC) [10]
DE (Uniform)	37	36	24	16	17	19	21	21	13	11	DE (Uniform) [9]
IPOP-aCMA-ES	3.6	3.7	**3.3**	**3.4**	**3.7**	**4.0**	**4.1**	**3.8**	**2.3**	**1.9**	IPOP-aCMA-ES [16]
IPOP-CMA-ES	3.4	3.2	**2.0**	**2.6**	**3.7**	**4.4**	**4.6**	**4.4**	**2.7**	**2.2**	IPOP-CMA-ES [22]
CMA+DE-MOS	13	12	9.1	9.4	11	11	12	11	6.3	5.0	CMA+DE-MOS [18]
NBC-CMA	5.9	5.5	**3.4**	5.6	7.1	8.6	9.0	8.4	5.1	4.2	NBC-CMA [21]
POEMS	159	163	3019	6767	33921	*40e-1/3e5*	.	.	.	.	POEMS [17]
PM-AdapSS-DE	30	30	19	14	15	17	19	20	13	11	PM-AdapSS-DE [9, 10]
pPOEMS	535	736	992	3368	10102	30597	27208	21660	*92e-2/3e5*	.	pPOEMS [17, 20]
Basic RCGA	121	162	120	261	1179	2405	*39e-2/5e4*	.	.	.	Basic RCGA [24]
SPSA	3471	2878	4252	*21e+0/1e5*	.	.	.	.	.	.	SPSA [13]

Table 85: Running time excess $\mathrm{ERT}/\mathrm{ERT}_{\text{best 2009}}$ on f_{13} in **10-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

13 Sharp ridge

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
$\mathrm{ERT}_{\text{best}}$/D	1.2	7.8	39	60	80	101	459	534	621	778	$\mathrm{ERT}_{\text{best}}$/D
(1,2)-CMA-ES	20	10	17	29	51	91	42	130	233	*44e-4/1e4*	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	6.8	5.3	10	26	37	53	24	58	108	*37e-5/1e4*	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	6.1	6.7	4.2	15	20	46	26	82	110	182	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	15	9.1	19	45	99	188	99	280	*18e-3/1e4*	.	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	5.7	4.5	6.5	15	18	17	9.3	14	20	27	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	4.1	3.9	5.0	13	14	13	5.5	6.4	15	39	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	**3.2**	3.3	3.9	6.4	12	12	4.3	4.9	6.1	19	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	4.9	3.6	6.4	14	13	16	6.3	6.7	11	26	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	3.9	**3.2**	**3.1**	6.5	**6.1**	10	**2.5**	**2.4**	4.0	5.9	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	**2.7**	**2.6**	4.3	**6.0**	7.0	**8.8**	**2.8**	**2.9**	**2.7**	6.6	(1+2ms)-CMA-ES [2]
Artif Bee Colony	15	26	19	202	2453	*18e-2/1e5*	.	.	.	.	Artif Bee Colony [8]
avg NEWUOA	**3.6**	**1.4**	**3.0**	13	30	76	32	70	278	*39e-5/1e4*	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	12	7.3	6.2	21	316	887	196	380	448	1804	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	16	33	12	12	12	11	3.0	3.0	**3.0**	**2.9**	Adap DE (F-AUC) [10]
DE (Uniform)	17	43	17	17	17	16	4.4	4.4	4.3	4.3	DE (Uniform) [9]
IPOP-aCMA-ES	4.2	4.9	**2.4**	**3.5**	**3.2**	**3.3**	**1.00**	**1.0**	**1.0**	**1.1**	IPOP-aCMA-ES [16]
IPOP-CMA-ES	5.6	5.4	3.8	**5.0**	**5.1**	**4.4**	**1.2**	**1.2**	**1.5**	**1.6**	IPOP-CMA-ES [22]
CMA+DE-MOS	9.2	19	7.3	12	15	12	3.2	3.2	3.1	3.0	CMA+DE-MOS [18]
NBC-CMA	7.6	9.4	4.4	10	11	9.0	**2.8**	**2.7**	3.2	3.5	NBC-CMA [21]
POEMS	191	139	85	3446	15152	19327	*61e-2/3e5*	.	.	.	POEMS [17]
PM-AdapSS-DE	20	36	14	14	13	13	3.5	3.5	3.4	3.4	PM-AdapSS-DE [9, 10]
pPOEMS	182	167	291	812	3189	12540	9357	8099	7024	*70e-3/3e5*	pPOEMS [17, 20]
Basic RCGA	11	88	158	1230	2678	7130	*17e-1/5e4*	.	.	.	Basic RCGA [24]
SPSA	93	894	12420	*13e+0/1e5*	.	.	.	.	.	.	SPSA [13]

Table 86: Running time excess ERT/$\text{ERT}_{\text{best 2009}}$ on f_{14} in **10-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

14 Sum of different powers

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
ERT_{best}/D	0.10	0.10	3.7	10	13	20	39	50	69	430	ERT_{best}/D
(1,2)-CMA-ES	**1**	3.8	9.1	6.7	6.9	7.6	7.9	10	12	4.3	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	**1**	4.0	4.2	3.7	3.9	4.2	4.4	6.3	7.7	**2.5**	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	**1**	**2.9**	3.4	**2.8**	3.0	3.3	3.6	5.3	6.7	**2.1**	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	**1**	23	10	6.6	7.1	7.7	7.6	11	13	4.0	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	**1**	7.5	**2.8**	**2.8**	3.2	3.7	3.6	5.3	6.1	**1.8**	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	**1**	3.3	**2.3**	**2.4**	**2.7**	**3.0**	3.1	4.4	5.5	**1.6**	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	**1**	**1.9**	**2.1**	**1.9**	**2.2**	**2.5**	**2.6**	**3.6**	**4.4**	**1.3**	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	**1**	7.3	**2.8**	**2.5**	**2.9**	3.1	3.1	4.1	4.8	**1.4**	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	**1**	3.4	**2.0**	**1.9**	**2.3**	**2.4**	**2.4**	3.8	4.9	**1.1**	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	**1**	3.1	**1.8**	**1.6**	**2.0**	**2.1**	**2.1**	**3.0**	**3.7**	**1.0**	(1+2ms)-CMA-ES [2]
Artif Bee Colony	**1**	**1.9**	6.4	17	22	35	703	*64e-5/1e5*	.	.	Artif Bee Colony [8]
avg NEWUOA	**1**	9.2	**1.7**	**1.3**	**1.3**	**1.2**	**1.1**	**2.2**	7.1	64	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	8.9	71	9.2	5.7	6.1	6.2	8.4	19	26	64	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	**1**	**2.1**	10	18	26	24	16	15	13	**2.8**	Adap DE (F-AUC) [10]
DE (Uniform)	**1**	**2.0**	9.5	25	34	33	22	22	19	4.1	DE (Uniform) [9]
IPOP-aCMA-ES	**1**	3.7	**2.1**	**2.8**	3.7	3.8	3.1	3.6	**3.5**	**0.84**	IPOP-aCMA-ES [16]
IPOP-CMA-ES	**1**	5.4	**2.2**	**2.9**	3.8	4.2	3.8	4.8	5.0	**1.3**	IPOP-CMA-ES [22]
CMA+DE-MOS	**1**	3.0	7.5	13	14	14	13	15	14	3.2	CMA+DE-MOS [18]
NBC-CMA	**1**	**2.3**	5.2	5.7	6.5	6.3	5.1	6.6	7.1	**1.9**	NBC-CMA [21]
POEMS	**1**	847	73	53	105	142	116	186	1491	*33e-7/3e5*	POEMS [17]
PM-AdapSS-DE	**1**	**1.9**	13	21	29	27	19	18	15	3.2	PM-AdapSS-DE [9, 10]
pPOEMS	**1**	103	73	61	193	496	570	818	987	*61e-8/3e5*	pPOEMS [17, 20]
Basic RCGA	**1**	**2.1**	5.5	30	44	91	1052	13979	*76e-5/5e4*	.	Basic RCGA [24]
SPSA	21	348	97	74	61	49	53	293	1046	*43e-7/1e5*	SPSA [13]

Table 87: Running time excess $\mathrm{ERT}/\mathrm{ERT}_{\text{best 2009}}$ on f_{15} in **10-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

15 Rastrigin

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
$\mathrm{ERT}_{\text{best}}$/D	0.10	19	477	3925	7364	7467	7579	7674	7781	7983	$\mathrm{ERT}_{\text{best}}$/D
(1,2)-CMA-ES	8.3	18	*31e+0/1e4*	.	.	.	.	.	.	.	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	**1.1**	**2.0**	72	*14e+0/1e4*	.	.	.	.	.	.	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	**1.5**	**2.0**	62	*12e+0/1e4*	.	.	.	.	.	.	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	4.5	39	*29e+0/1e4*	.	.	.	.	.	.	.	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	**1.4**	4.8	146	*15e+0/1e4*	.	.	.	.	.	.	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	**1.6**	**1.1**	55	*11e+0/1e4*	.	.	.	.	.	.	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	**1**	**1.6**	24	*90e-1/1e4*	.	.	.	.	.	.	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	**1.7**	4.1	137	*13e+0/1e4*	.	.	.	.	.	.	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	3.5	3.6	148	*16e+0/1e4*	.	.	.	.	.	.	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	4.8	5.2	143	*16e+0/1e4*	.	.	.	.	.	.	(1+2ms)-CMA-ES [2]
Artif Bee Colony	**1.7**	7.3	*14e+0/1e5*	.	.	.	.	.	.	.	Artif Bee Colony [8]
avg NEWUOA	5.5	4.3	231	*25e+0/7e3*	.	.	.	.	.	.	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	61	**1.8**	17	370	*30e-1/1e5*	.	.	.	.	.	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	**1.8**	6.1	65	110	194	191	188	186	183	179	Adap DE (F-AUC) [10]
DE (Uniform)	**2.2**	7.8	68	50	93	92	91	89	88	86	DE (Uniform) [9]
IPOP-aCMA-ES	**2.3**	**0.99**	**0.91**	**1.0**	**0.83**	**0.84**	**0.84**	**0.85**	**0.85**	**0.86**	IPOP-aCMA-ES [16]
IPOP-CMA-ES	4.1	**1.2**	**1.3**	**1.0**	**0.82**	**0.82**	**0.83**	**0.83**	**0.84**	**0.85**	IPOP-CMA-ES [22]
CMA+DE-MOS	**2.1**	4.4	**1.3**	**1.7**	**1.3**	**1.3**	**1.3**	**1.3**	**1.3**	**1.3**	CMA+DE-MOS [18]
NBC-CMA	**1.7**	**2.2**	**2.5**	108	*30e-1/3e4*	.	.	.	.	.	NBC-CMA [21]
POEMS	438	18	321	*80e-1/3e5*	.	.	.	.	.	.	POEMS [17]
PM-AdapSS-DE	**2.1**	7.1	72	18	17	26	59	189	*66e-3/1e5*	.	PM-AdapSS-DE [9, 10]
pPOEMS	**1.8**	18	140	*60e-1/3e5*	.	.	.	.	.	.	pPOEMS [17, 20]
Basic RCGA	**1.4**	5.0	17	86	98	97	96	94	93	91	Basic RCGA [24]
SPSA	6.71e5	3796	*72e+0/1e5*	.	.	.	.	.	.	.	SPSA [13]

Table 88: Running time excess ERT/ERT$_{\text{best 2009}}$ on f_{16} in **10-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

16 Weierstrass

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
ERT$_{\text{best}}$/D	0.10	0.10	43	703	1578	4567	5115	6511	6580	7157	ERT$_{\text{best}}$/D
(1,2)-CMA-ES	**1**	**1.7**	553	*11e+0/1e4*	.	.	.	.	.	.	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	**1**	**1.4**	26	96	*25e-1/1e4*	.	.	.	.	.	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	**1**	**1.3**	32	96	*32e-1/1e4*	.	.	.	.	.	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	**1**	**1.3**	779	*15e+0/1e4*	.	.	.	.	.	.	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	**1**	**1.5**	22	45	*20e-1/1e4*	.	.	.	.	.	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	**1**	**1.4**	11	14	91	*64e-2/1e4*	.	.	.	.	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	**1**	**1.4**	12	24	*13e-1/1e4*	.	.	.	.	.	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	**1**	**1.5**	27	97	*28e-1/1e4*	.	.	.	.	.	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	**1**	**1.7**	5.2	46	*16e-1/1e4*	.	.	.	.	.	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	**1**	**1.2**	4.2	97	*13e-1/1e4*	.	.	.	.	.	(1+2ms)-CMA-ES [2]
Artif Bee Colony	**1**	**1.3**	3.3	149	*92e-2/1e5*	.	.	.	.	.	Artif Bee Colony [8]
avg NEWUOA	**1**	**1.5**	**3.3**	41	*13e-1/1e4*	.	.	.	.	.	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	**1**	53	14	20	89	308	*10e-2/1e5*	.	.	.	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	**1**	**1.7**	70	*51e-1/1e5*	.	.	.	.	.	.	Adap DE (F-AUC) [10]
DE (Uniform)	**1**	**1.7**	104	*45e-1/1e5*	.	.	.	.	.	.	DE (Uniform) [9]
IPOP-aCMA-ES	**1**	**1.3**	**1.6**	**0.95**	**1.2**	**0.84**	**1.1**	**0.91**	**0.92**	**0.87**	IPOP-aCMA-ES [16]
IPOP-CMA-ES	**1**	**1.3**	3.5	**1.2**	**1.2**	**0.87**	**0.90**	**0.72**	**0.75**	**0.71**	IPOP-CMA-ES [22]
CMA+DE-MOS	**1**	**1.3**	**2.6**	**0.55**	**0.99**	**1.2**	**1.4**	**1.1**	**1.2**	**1.2**	CMA+DE-MOS [18]
NBC-CMA	**1**	**1.5**	9.4	**0.71**	**1.3**	**1.8**	**2.9**	3.5	11	19	NBC-CMA [21]
POEMS	**1**	**1**	11	3.8	130	428	382	301	298	274	POEMS [17]
PM-AdapSS-DE	**1**	**1.5**	70	*34e-1/1e5*	.	.	.	.	.	.	PM-AdapSS-DE [9, 10]
pPOEMS	**1**	**1.3**	16	18	89	189	243	192	192	178	pPOEMS [17, 20]
Basic RCGA	**1**	**1.3**	7.9	13	38	50	142	112	*87e-3/5e4*	.	Basic RCGA [24]
SPSA	**1**	1551	1239	2107	*56e-1/1e5*	.	.	.	.	.	SPSA [13]

Table 89: Running time excess ERT/$\text{ERT}_{\text{best 2009}}$ on f_{17} in **10-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

17 Schaffer F7, condition 10

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
ERT_{best}/D	0.10	0.10	2.6	43	220	633	985	1534	2019	2650	ERT_{best}/D
(1,2)-CMA-ES	**1**	**2.5**	119	3362	*25e-1/1e4*	.	.	.	.	.	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	**1**	**2.7**	5.5	55	196	229	*18e-2/1e4*	.	.	.	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	**1**	**1.1**	31	52	327	*34e-2/1e4*	.	.	.	.	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	**1**	**1.2**	204	3343	*24e-1/1e4*	.	.	.	.	.	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	**1**	**1**	9.3	82	*38e-2/1e4*	.	.	.	.	.	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	**1**	**1**	3.1	22	324	*24e-2/1e4*	.	.	.	.	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	**1**	**1.1**	**2.6**	51	214	*15e-2/1e4*	.	.	.	.	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	**1**	**1.7**	3.4	121	*69e-2/1e4*	.	.	.	.	.	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	**1**	**1.3**	17	443	*13e-1/1e4*	.	.	.	.	.	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	**1**	**1**	6.2	717	*13e-1/1e4*	.	.	.	.	.	(1+2ms)-CMA-ES [2]
Artif Bee Colony	**1**	**1.2**	11	954	*65e-2/1e5*	.	.	.	.	.	Artif Bee Colony [8]
avg NEWUOA	**1**	**1.1**	**2.2**	987	*10e-1/3e4*	.	.	.	.	.	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	24	59	6.2	**1.4**	**0.77**	**0.74**	**2.0**	4.4	70	530	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	**1**	**1.1**	7.4	8.0	3.2	**1.8**	**1.6**	**1.4**	**1.5**	**1.5**	Adap DE (F-AUC) [10]
DE (Uniform)	**1**	**1.1**	5.4	11	4.6	**2.7**	**2.4**	**2.1**	**2.0**	**2.0**	DE (Uniform) [9]
IPOP-aCMA-ES	**1**	**1.1**	**2.4**	**1.2**	**1.8**	**1.2**	**1.3**	**1.0**	**1.0**	**1.0**	IPOP-aCMA-ES [16]
IPOP-CMA-ES	**1**	**1.6**	**2.7**	**2.6**	**1.5**	**0.83**	**1.0**	**0.90**	**0.88**	**1.0**	IPOP-CMA-ES [22]
CMA+DE-MOS	**1**	**1.4**	3.3	30	10	4.1	3.3	4.8	3.8	3.3	CMA+DE-MOS [18]
NBC-CMA	**1**	**1.1**	**2.9**	**1.8**	**0.72**	**0.87**	**1.6**	7.7	31	*16e-6/3e4*	NBC-CMA [21]
POEMS	**1**	274	86	24	111	42	84	104	178	1591	POEMS [17]
PM-AdapSS-DE	**1**	**1.2**	4.6	8.5	3.6	**2.0**	**1.8**	**1.5**	**1.5**	**1.5**	PM-AdapSS-DE [9, 10]
pPOEMS	**1**	**1.2**	91	32	72	54	52	45	44	146	pPOEMS [17, 20]
Basic RCGA	**1**	**1.1**	5.8	16	48	36	40	50	111	*16e-5/5e4*	Basic RCGA [24]
SPSA	6.67e5	8.76e5	34195	32685	*86e-1/1e5*	.	.	.	.	.	SPSA [13]

Table 90: Running time excess $\mathrm{ERT}/\mathrm{ERT}_{\text{best 2009}}$ on f_{18} in **10-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

18 Schaffer F7, condition 1000

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
$\mathrm{ERT}_{\text{best}}$/D	0.10	0.19	24	84	701	1593	2754	3161	3723	4271	$\mathrm{ERT}_{\text{best}}$/D
(1,2)-CMA-ES	**2.6**	18	139	*78e-1/1e4*	.	.	.	.	.	.	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	**1**	4.2	**1.8**	171	*11e-1/1e4*	.	.	.	.	.	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	**1.1**	8.8	7.6	224	*13e-1/1e4*	.	.	.	.	.	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	**1.9**	19	297	*74e-1/1e4*	.	.	.	.	.	.	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	**1**	10	61	384	*18e-1/1e4*	.	.	.	.	.	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	**1**	5.7	13	82	205	*58e-2/1e4*	.	.	.	.	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	**1**	**1.8**	6.4	137	*83e-2/1e4*	.	.	.	.	.	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	**1**	6.6	39	811	*23e-1/1e4*	.	.	.	.	.	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	**1.4**	6.6	93	*48e-1/1e4*	.	.	.	.	.	.	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	**1**	**2.5**	63	*39e-1/1e4*	.	.	.	.	.	.	(1+2ms)-CMA-ES [2]
Artif Bee Colony	**1**	4.7	63	7923	*18e-1/1e5*	.	.	.	.	.	Artif Bee Colony [8]
avg NEWUOA	**1**	10	73	*32e-1/9e4*	.	.	.	.	.	.	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	40	46	**1.8**	4.7	3.7	4.3	23	135	*54e-5/1e5*	.	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	**1**	**2.9**	7.6	6.5	**1.4**	**0.96**	**0.76**	**0.81**	**0.90**	**0.99**	Adap DE (F-AUC) [10]
DE (Uniform)	**1.3**	3.4	9.5	9.0	**2.0**	**1.3**	**1.0**	**1.1**	**1.2**	**1.4**	DE (Uniform) [9]
IPOP-aCMA-ES	**1**	7.7	**1.2**	**1.6**	**0.82**	**0.97**	**0.78**	**0.88**	**0.80**	**0.88**	IPOP-aCMA-ES [16]
IPOP-CMA-ES	**1**	**2.1**	**1.1**	**1.7**	**0.95**	**0.95**	**0.84**	**1.0**	**0.97**	**0.91**	IPOP-CMA-ES [22]
CMA+DE-MOS	**1.1**	**2.8**	5.4	3.5	**0.85**	**1.2**	**0.87**	**1.0**	**1.1**	**1.3**	CMA+DE-MOS [18]
NBC-CMA	**1**	3.0	**2.0**	**1.5**	**0.54**	**2.4**	9.1	139	118	*31e-5/3e4*	NBC-CMA [21]
POEMS	**1**	613	20	285	162	287	439	1332	*25e-3/3e5*	.	POEMS [17]
PM-AdapSS-DE	**1.1**	**1.8**	8.4	7.4	**1.6**	**1.1**	**0.81**	**0.89**	**0.95**	**1.0**	PM-AdapSS-DE [9, 10]
pPOEMS	**1**	74	20	116	42	46	54	93	123	230	pPOEMS [17, 20]
Basic RCGA	**1**	**1.6**	8.3	114	36	48	58	229	*14e-3/5e4*	.	Basic RCGA [24]
SPSA	8.78e5	1.04e6	*66e+1/1e5*	.	.	.	.	.	.	.	SPSA [13]

Table 91: Running time excess ERT/$\text{ERT}_{\text{best 2009}}$ on f_{19} in **10-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

19 Griewank-Rosenbrock F8F2

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
ERT_{best}/D	0.10	0.10	0.10	0.10	1061	98379	1.37e5	1.37e5	1.38e5	1.39e5	ERT_{best}/D
(1,2)-CMA-ES	**1**	**1**	514	7.33e5	*24e-1/1e4*	.	.	.	.	.	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	**1**	**1**	128	1.55e5	*90e-2/1e4*	.	.	.	.	.	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	**1**	**1**	164	2.24e5	*11e-1/1e4*	.	.	.	.	.	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	**1**	**1**	239	1.46e6	*32e-1/1e4*	.	.	.	.	.	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	**1**	**1**	82	1.99e5	*13e-1/1e4*	.	.	.	.	.	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	**1**	**1**	68	45284	*58e-2/1e4*	.	.	.	.	.	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	**1**	**1**	57	43406	*68e-2/1e4*	.	.	.	.	.	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	**1**	**1**	79	75584	*77e-2/1e4*	.	.	.	.	.	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	**1**	**1**	63	65610	*85e-2/1e4*	.	.	.	.	.	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	**1**	**1**	**54**	22281	*55e-2/1e4*	.	.	.	.	.	(1+2ms)-CMA-ES [2]
Artif Bee Colony	**1**	**1.1**	410	4.22e6	*12e-1/1e5*	.	.	.	.	.	Artif Bee Colony [8]
avg NEWUOA	**1**	**1**	**48**	7.08e5	*83e-2/1e5*	.	.	.	.	.	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	23	64	223	28056	422	*20e-2/1e5*	.	.	.	.	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	**1**	**1.2**	303	4.04e5	*59e-2/1e5*	.	.	.	.	.	Adap DE (F-AUC) [10]
DE (Uniform)	**1**	**1.2**	390	8.37e5	*52e-2/1e5*	.	.	.	.	.	DE (Uniform) [9]
IPOP-aCMA-ES	**1**	**1**	68	**9042**	**10**	**0.61**	**0.53**	**0.53**	**0.53**	**0.54**	IPOP-aCMA-ES [16]
IPOP-CMA-ES	**1**	**1**	**56**	**12509**	**8.9**	**0.55**	**0.53**	**0.53**	**0.53**	**0.53**	IPOP-CMA-ES [22]
CMA+DE-MOS	**1**	**1.1**	212	**5852**	**6.5**	**1.2**	**1.1**	**1.1**	**1.1**	**1.1**	CMA+DE-MOS [18]
NBC-CMA	**1**	**1.2**	117	2.11e6	*15e-1/3e4*	.	.	.	.	.	NBC-CMA [21]
POEMS	**1**	253	2538	5.19e5	4011	*55e-2/3e5*	.	.	.	.	POEMS [17]
PM-AdapSS-DE	**1**	**1.7**	256	5.48e5	*81e-2/1e5*	.	.	.	.	.	PM-AdapSS-DE [9, 10]
pPOEMS	**1**	**1.2**	2624	3.58e5	4022	*23e-2/3e5*	.	.	.	.	pPOEMS [17, 20]
Basic RCGA	**1**	**1.2**	167	70727	157	*17e-2/5e4*	.	.	.	.	Basic RCGA [24]
SPSA	44	126	658	6.65e6	*18e-1/1e5*	.	.	.	.	.	SPSA [13]

Table 92: Running time excess ERT/ERT$_{\text{best 2009}}$ on f_{20} in **10-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

20 Schwefel x*sin(x)

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
ERT$_{\text{best}}$/D	2.6	3.0	3.2	1543	55001	56739	57252	57645	58096	58926	ERT$_{\text{best}}$/D
(1,2)-CMA-ES	11	12	12	10	*99e-2/1e4*	.	.	.	.	.	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	6.2	6.6	6.7	5.6	*91e-2/1e4*	.	.	.	.	.	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	5.7	5.8	5.9	**2.3**	*87e-2/1e4*	.	.	.	.	.	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	11	11	12	9.5	*10e-1/1e4*	.	.	.	.	.	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	4.9	5.1	5.3	**2.6**	*89e-2/1e4*	.	.	.	.	.	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	3.9	4.5	4.5	**2.3**	*79e-2/1e4*	.	.	.	.	.	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	**3.2**	3.6	3.9	**2.6**	*69e-2/1e4*	.	.	.	.	.	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	3.8	4.0	4.4	3.1	*87e-2/1e4*	.	.	.	.	.	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	3.4	**3.4**	**3.8**	3.9	*87e-2/1e4*	.	.	.	.	.	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	**2.5**	**2.7**	**2.9**	3.3	*83e-2/1e4*	.	.	.	.	.	(1+2ms)-CMA-ES [2]
Artif Bee Colony	8.6	9.5	10	**0.18**	**1.3**	**1.3**	**1.3**	**1.4**	**2.1**	6.0	Artif Bee Colony [8]
avg NEWUOA	**1.5**	**1.3**	**1.2**	37	*12e-1/8e3*	.	.	.	.	.	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	10	11	11	*18e-1/1e5*	.	.	.	.	.	.	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	19	27	28	18	26	25	25	25	25	24	Adap DE (F-AUC) [10]
DE (Uniform)	30	35	38	15	5.4	5.3	5.2	5.2	5.1	5.1	DE (Uniform) [9]
IPOP-aCMA-ES	3.4	4.3	4.3	**2.3**	**0.84**	**0.86**	**0.87**	**0.87**	**0.88**	**0.89**	IPOP-aCMA-ES [16]
IPOP-CMA-ES	3.5	4.3	4.6	**2.8**	**0.78**	**0.79**	**0.79**	**0.80**	**0.80**	**0.81**	IPOP-CMA-ES [22]
CMA+DE-MOS	15	20	21	**0.76**	**0.14**	**0.19**	**0.26**	**0.29**	**0.30**	**0.42**	CMA+DE-MOS [18]
NBC-CMA	6.2	11	12	5.9	*77e-2/3e4*	.	.	.	.	.	NBC-CMA [21]
POEMS	99	100	104	**1.1**	15	15	15	15	14	14	POEMS [17]
PM-AdapSS-DE	24	30	31	23	*36e-2/1e5*	.	.	.	.	.	PM-AdapSS-DE [9, 10]
pPOEMS	104	105	104	3.4	15	15	15	15	15	15	pPOEMS [17, 20]
Basic RCGA	10	13	14	484	*17e-1/5e4*	.	.	.	.	.	Basic RCGA [24]
SPSA	12	15	19	*19e-1/1e5*	.	.	.	.	.	.	SPSA [13]

Table 93: Running time excess ERT/$\text{ERT}_{\text{best 2009}}$ on f_{21} in **10-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

21 Gallagher 101 peaks

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
ERT_{best}/D	0.10	0.10	13	224	439	449	462	486	507	1133	ERT_{best}/D
(1,2)-CMA-ES	**1**	**1**	18	14	22	21	21	20	19	8.4	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	**1**	**1**	8.4	11	14	14	13	13	12	5.5	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	**1**	**1**	4.3	**5.4**	7.3	7.1	7.0	6.6	6.4	**2.9**	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	**1**	**1**	39	20	18	18	17	17	16	7.2	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	**1**	**1**	6.2	6.4	11	11	10	10	10	4.3	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	**1**	**1**	4.2	6.7	**4.7**	**4.6**	**4.5**	**4.3**	**4.1**	**1.9**	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	**1**	**1**	4.8	**4.3**	**3.6**	**3.5**	**3.4**	**3.3**	**3.1**	**1.4**	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	**1**	**1**	7.0	6.4	6.9	6.8	6.6	6.3	6.0	**2.7**	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	**1**	**1**	4.2	6.3	**4.4**	**4.3**	**4.2**	**4.0**	**3.8**	**1.7**	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	**1**	**1**	**4.1**	6.5	6.0	5.8	5.7	5.4	5.2	**2.3**	(1+2ms)-CMA-ES [2]
Artif Bee Colony	**1**	**1**	8.0	**2.9**	8.5	10	12	24	39	82	Artif Bee Colony [8]
avg NEWUOA	**1**	**1**	**3.2**	8.2	4.7	4.7	4.5	4.3	4.1	**1.9**	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	**1**	62	13	101	60	59	58	56	55	25	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	**1**	**1**	23	114	84	83	81	77	74	33	Adap DE (F-AUC) [10]
DE (Uniform)	**1**	**1**	25	115	116	113	110	105	101	45	DE (Uniform) [9]
IPOP-aCMA-ES	**1**	**1**	**2.6**	31	58	57	55	53	50	23	IPOP-aCMA-ES [16]
IPOP-CMA-ES	**1**	**1**	5.9	14	52	51	50	47	45	21	IPOP-CMA-ES [22]
CMA+DE-MOS	**1**	**1**	25	347	512	503	489	466	447	201	CMA+DE-MOS [18]
NBC-CMA	**1**	**1**	12	275	188	184	179	170	163	73	NBC-CMA [21]
POEMS	**1**	**1**	3498	2668	1648	1615	1570	1494	1431	642	POEMS [17]
PM-AdapSS-DE	**1**	**1**	18	226	262	256	249	237	227	102	PM-AdapSS-DE [9, 10]
pPOEMS	**1**	**1**	38	746	980	1122	1317	1259	1211	547	pPOEMS [17, 20]
Basic RCGA	**1**	**1**	121	120	86	86	86	84	82	38	Basic RCGA [24]
SPSA	**1**	102	94	1309	1543	1515	1488	2894	2780	1272	SPSA [13]

Table 94: Running time excess ERT/ERT$_{\text{best 2009}}$ on f_{22} in **10-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

22 Gallagher 21 peaks

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
ERT$_{\text{best}}$/D	0.10	0.10	10	284	635	662	680	692	830	1035	ERT$_{\text{best}}$/D
(1,2)-CMA-ES	**1**	**1**	19	9.2	30	29	28	28	23	19	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	**1**	**1**	18	9.3	18	17	16	16	14	11	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	**1**	**1**	20	11	25	24	24	23	19	16	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	**1**	**1**	62	12	40	39	38	37	31	25	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	**1**	**1**	15	7.0	10	9.3	9.1	9.0	7.5	6.1	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	**1**	**1**	12	6.6	12	11	11	11	8.9	7.2	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	**1**	**1**	**8.2**	**4.1**	14	14	14	13	11	8.9	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	**1**	**1**	16	8.4	13	13	12	12	10	8.2	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	**1**	**1**	**9.3**	4.5	**4.0**	**3.8**	**3.8**	**3.7**	**3.1**	**2.5**	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	**1**	**1**	22	4.5	**5.0**	**4.8**	**4.7**	**4.6**	**3.9**	**3.1**	(1+2ms)-CMA-ES [2]
Artif Bee Colony	**1**	**1**	17	**4.3**	34	364	*13e-3/1e5*	.	.	.	Artif Bee Colony [8]
avg NEWUOA	**1**	**1**	**3.6**	**2.6**	**2.1**	**2.1**	**2.0**	**2.0**	**1.7**	**1.4**	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	**1**	53	22	417	1024	982	957	939	784	628	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	**1**	**1**	32	706	*20e-1/1e5*	.	.	.	.	.	Adap DE (F-AUC) [10]
DE (Uniform)	**1**	**1**	31	405	2206	2117	2061	2024	1689	1354	DE (Uniform) [9]
IPOP-aCMA-ES	**1**	**1**	44	203	663	636	620	608	508	407	IPOP-aCMA-ES [16]
IPOP-CMA-ES	**1**	**1**	42	90	666	640	623	612	510	409	IPOP-CMA-ES [22]
CMA+DE-MOS	**1**	**1**	171	538	1268	1218	1187	1166	974	781	CMA+DE-MOS [18]
NBC-CMA	**1**	**1**	792	221	*51e-1/3e4*	.	.	.	.	.	NBC-CMA [21]
POEMS	**1**	**1**	4774	4231	3072	2950	2873	2822	2356	1892	POEMS [17]
PM-AdapSS-DE	**1**	**1**	28	706	*20e-1/1e5*	.	.	.	.	.	PM-AdapSS-DE [9, 10]
pPOEMS	**1**	**1**	2258	363	424	412	404	401	338	276	pPOEMS [17, 20]
Basic RCGA	**1**	**1**	711	205	343	520	*69e-2/5e4*	.	.	.	Basic RCGA [24]
SPSA	3.3	69	2954	831	*51e-1/1e5*	.	.	.	.	.	SPSA [13]

Table 95: Running time excess ERT/ERT$_{\text{best 2009}}$ on f_{23} in **10-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

23 Katsuuras

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
ERT$_{\text{best}}$/D	0.10	0.10	0.28	92	1643	18390	20350	20641	20893	21351	ERT$_{\text{best}}$/D
(1,2)-CMA-ES	**1**	**1**	38	1557	*14e-1/1e4*	.	.	.	.	.	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	**1**	**1**	4.7	68	*35e-2/1e4*	.	.	.	.	.	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	**1**	**1**	8.6	70	*39e-2/1e4*	.	.	.	.	.	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	**1**	**1**	44	797	*14e-1/1e4*	.	.	.	.	.	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	**1**	**1**	7.5	33	*35e-2/1e4*	.	.	.	.	.	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	**1**	**1**	5.7	33	*34e-2/1e4*	.	.	.	.	.	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	**1**	**1**	5.0	15	91	*23e-2/1e4*	.	.	.	.	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	**1**	**1**	5.7	58	*60e-2/1e4*	.	.	.	.	.	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	**1**	**1**	6.5	**4.5**	*28e-2/1e4*	.	.	.	.	.	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	**1**	**1**	5.1	**4.5**	*26e-2/1e4*	.	.	.	.	.	(1+2ms)-CMA-ES [2]
Artif Bee Colony	**1**	**1**	**2.5**	33	*49e-2/1e5*	.	.	.	.	.	Artif Bee Colony [8]
avg NEWUOA	**1**	**1**	11	**2.6**	*21e-2/1e4*	.	.	.	.	.	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	**1**	35	34	397	*84e-2/1e5*	.	.	.	.	.	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	**1**	**1**	**2.3**	85	160	*15e-2/1e5*	.	.	.	.	Adap DE (F-AUC) [10]
DE (Uniform)	**1**	**1**	**1.5**	97	278	**80**	**72**	**71**	**70**	**69**	DE (Uniform) [9]
IPOP-aCMA-ES	**1**	**1**	**1.8**	458	*71e-2/2e5*	.	.	.	.	.	IPOP-aCMA-ES [16]
IPOP-CMA-ES	**1**	**1**	**2.4**	376	308	**65**	**59**	**58**	**57**	**56**	IPOP-CMA-ES [22]
CMA+DE-MOS	**1**	**1**	**1.7**	24	**15**	**4.0**	**3.6**	**3.6**	**3.6**	**3.5**	CMA+DE-MOS [18]
NBC-CMA	**1**	**1**	**1.4**	692	*11e-1/3e4*	.	.	.	.	.	NBC-CMA [21]
POEMS	**1**	**1**	9.1	26	**50**	107	*36e-3/3e5*	.	.	.	POEMS [17]
PM-AdapSS-DE	**1**	**1**	**1.6**	81	*28e-2/1e5*	.	.	.	.	.	PM-AdapSS-DE [9, 10]
pPOEMS	**1**	**1**	5.7	161	**77**	111	211	*25e-3/3e5*	.	.	pPOEMS [17, 20]
Basic RCGA	**1**	**1**	**2.5**	162	436	*44e-2/5e4*	.	.	.	.	Basic RCGA [24]
SPSA	**1**	173	1046	3799	*11e-1/1e5*	.	.	.	.	.	SPSA [13]

Table 96: Running time excess ERT/$\text{ERT}_{\text{best 2009}}$ on f_{24} in **10-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

24 Lunacek bi-Rastrigin

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
ERT_{best}/D	0.10	6.6	9876	1.04e5	7.47e6	7.48e6	7.48e6	7.48e6	7.48e6	7.48e6	ERT_{best}/D
(1,2)-CMA-ES	**1**	54	*50e+0/1e4*	.	.	.	.	.	.	.	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	**1**	4.7	*23e+0/1e4*	.	.	.	.	.	.	.	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	**1**	5.9	*22e+0/1e4*	.	.	.	.	.	.	.	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	**1**	71	*53e+0/1e4*	.	.	.	.	.	.	.	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	**1**	4.9	15	*25e+0/1e4*	.	.	.	.	.	.	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	**1**	3.6	**4.8**	*12e+0/1e4*	.	.	.	.	.	.	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	**1**	**2.7**	*17e+0/1e4*	.	.	.	.	.	.	.	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	**1**	4.8	*23e+0/1e4*	.	.	.	.	.	.	.	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	**1**	8.9	*24e+0/1e4*	.	.	.	.	.	.	.	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	**1**	4.2	**4.8**	*18e+0/1e4*	.	.	.	.	.	.	(1+2ms)-CMA-ES [2]
Artif Bee Colony	**1**	24	*24e+0/1e5*	.	.	.	.	.	.	.	Artif Bee Colony [8]
avg NEWUOA	**1**	**1.4**	*21e+0/8e3*	.	.	.	.	.	.	.	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	78	4.8	**3.6**	*41e-1/1e5*	.	.	.	.	.	.	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	**1**	16	47	*14e+0/1e5*	.	.	.	.	.	.	Adap DE (F-AUC) [10]
DE (Uniform)	**1**	20	47	*16e+0/1e5*	.	.	.	.	.	.	DE (Uniform) [9]
IPOP-aCMA-ES	**1**	**2.1**	50	**33**	*10e+0/2e5*	.	.	.	.	.	IPOP-aCMA-ES [16]
IPOP-CMA-ES	**1**	**2.0**	24	**6.9**	**0.48**	**0.48**	**0.48**	**0.48**	**0.48**	*81e-1/2e5*	IPOP-CMA-ES [22]
CMA+DE-MOS	**1**	11	5.8	**2.9**	**0.26**	**0.26**	**0.26**	**0.26**	**0.26**	**0.26**	CMA+DE-MOS [18]
NBC-CMA	**1**	4.9	*32e+0/3e4*	.	.	.	.	.	.	.	NBC-CMA [21]
POEMS	**1**	49	122	*16e+0/3e5*	.	.	.	.	.	.	POEMS [17]
PM-AdapSS-DE	**1**	16	69	*12e+0/1e5*	.	.	.	.	.	.	PM-AdapSS-DE [9, 10]
pPOEMS	**1**	47	24	*89e-1/3e5*	.	.	.	.	.	.	pPOEMS [17, 20]
Basic RCGA	**1**	7.3	37	*12e+0/5e4*	.	.	.	.	.	.	Basic RCGA [24]
SPSA	118	*32e+1/1e5*	.	.	.	.	.	.	.	.	SPSA [13]

Table 97: Running time excess $\mathrm{ERT}/\mathrm{ERT}_{\text{best 2009}}$ on f_1 in **20-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

1 Sphere

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
$\mathrm{ERT}_{\text{best}}$/D	0.05	0.28	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	$\mathrm{ERT}_{\text{best}}$/D
(1,2)-CMA-ES	**1**	63	15	25	34	44	53	63	72	93	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	**1**	26	8.9	15	20	25	30	35	41	52	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	**1**	25	8.1	13	18	22	27	32	36	47	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	**1**	63	17	26	35	44	53	62	72	89	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	**1**	18	7.7	13	18	23	27	33	38	49	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	**1**	15	6.2	11	15	19	24	28	32	42	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	**1**	14	**4.7**	**8.1**	**11**	**14**	**18**	**21**	**24**	**31**	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	**1**	17	6.3	11	15	19	23	26	31	40	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	**1**	11	5.5	10	14	18	21	25	29	37	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	**1**	**10**	**4.9**	**8.5**	**12**	**15**	**19**	**23**	**26**	**33**	(1+2ms)-CMA-ES [2]
Artif Bee Colony	**1**	50	36	66	94	136	177	244	292	374	Artif Bee Colony [8]
avg NEWUOA	**1**	18	**2.3**	**2.3**	**2.3**	**2.3**	**2.3**	**2.3**	**2.3**	**2.3**	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	47	41	13	19	26	33	40	47	54	68	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	**1**	79	93	180	265	350	431	515	597	763	Adap DE (F-AUC) [10]
DE (Uniform)	**1**	89	146	298	442	588	734	882	1027	1319	DE (Uniform) [9]
IPOP-aCMA-ES	**1**	**9.4**	7.9	14	20	27	33	39	45	58	IPOP-aCMA-ES [16]
IPOP-CMA-ES	**1**	**10**	8.0	14	20	26	33	39	46	58	IPOP-CMA-ES [22]
CMA+DE-MOS	**1**	34	34	58	68	91	123	134	148	200	CMA+DE-MOS [18]
NBC-CMA	**1**	17	13	21	30	38	46	54	62	79	NBC-CMA [21]
POEMS	**1**	804	183	411	853	1372	1783	2331	2828	3744	POEMS [17]
PM-AdapSS-DE	**1**	69	101	196	291	377	465	555	646	827	PM-AdapSS-DE [9, 10]
pPOEMS	**1**	847	196	468	1052	1852	2567	3510	4501	7123	pPOEMS [17, 20]
Basic RCGA	**1**	36	55	133	868	2715	3825	4686	5435	6380	Basic RCGA [24]
SPSA	158	59	12	16	20	25	29	34	38	46	SPSA [13]

Table 98: Running time excess ERT/ERT$_{\text{best 2009}}$ on f_2 in **20-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

2 Ellipsoid separable

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
ERT$_{\text{best}}$/D	19	19	19	19	19	19	19	20	20	20	ERT$_{\text{best}}$/D
(1,2)-CMA-ES	94	133	155	168	172	175	177	179	181	184	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	39	58	71	80	82	83	84	84	85	86	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	33	50	61	67	69	69	70	70	71	72	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	95	147	165	183	188	194	196	198	200	205	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	24	41	54	62	65	67	68	68	69	70	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	21	34	45	51	54	56	56	57	57	58	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	17	26	34	39	41	41	42	**42**	**43**	**43**	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	20	33	43	51	53	54	55	56	57	58	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	12	23	32	38	41	42	43	43	44	45	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	11	21	29	**33**	**35**	**35**	**36**	**36**	**37**	**37**	(1+2ms)-CMA-ES [2]
Artif Bee Colony	**6.3**	**8.1**	**12**	**16**	**24**	**30**	**40**	47	56	70	Artif Bee Colony [8]
avg NEWUOA	**3.5**	**10**	**21**	43	63	89	116	141	161	199	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	48	66	73	79	82	83	84	84	85	86	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	27	37	48	58	68	77	86	95	105	123	Adap DE (F-AUC) [10]
DE (Uniform)	45	61	77	92	108	124	140	157	172	203	DE (Uniform) [9]
IPOP-aCMA-ES	**10**	**17**	**22**	**27**	**29**	**30**	**31**	**32**	**33**	**34**	IPOP-aCMA-ES [16]
IPOP-CMA-ES	16	25	35	41	43	44	45	46	47	48	IPOP-CMA-ES [22]
CMA+DE-MOS	25	35	44	50	57	61	67	70	74	82	CMA+DE-MOS [18]
NBC-CMA	23	39	58	73	83	87	90	93	95	98	NBC-CMA [21]
POEMS	145	191	247	295	345	407	450	507	561	663	POEMS [17]
PM-AdapSS-DE	32	42	52	63	73	83	93	103	112	132	PM-AdapSS-DE [9, 10]
pPOEMS	151	216	305	423	513	661	744	895	1213	1404	pPOEMS [17, 20]
Basic RCGA	41	231	384	930	4447	4531	17394	*51e-2/5e4*	.	.	Basic RCGA [24]
SPSA	78570	*18e+2/1e5*	.	.	.	.	.	.	.	.	SPSA [13]

Table 99: Running time excess $\mathrm{ERT}/\mathrm{ERT}_{\text{best 2009}}$ on f_3 in **20-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

3 Rastrigin separable

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
$\mathrm{ERT}_{\text{best}}$/D	0.05	13	253	381	382	382	382	382	382	383	$\mathrm{ERT}_{\text{best}}$/D
(1,2)-CMA-ES	262	11707	*14e+1/1e4*	.	.	.	.	.	.	.	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	121	122	*63e+0/1e4*	.	.	.	.	.	.	.	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	89	133	*67e+0/1e4*	.	.	.	.	.	.	.	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	301	*16e+1/1e4*	.	.	.	.	.	.	.	.	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	75	122	*64e+0/1e4*	.	.	.	.	.	.	.	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	38	41	*54e+0/1e4*	.	.	.	.	.	.	.	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	42	55	*61e+0/1e4*	.	.	.	.	.	.	.	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	51	189	*73e+0/1e4*	.	.	.	.	.	.	.	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	30	472	*95e+0/1e4*	.	.	.	.	.	.	.	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	29	378	*84e+0/1e4*	.	.	.	.	.	.	.	(1+2ms)-CMA-ES [2]
Artif Bee Colony	32	7.7	**1.5**	**2.7**	**3.0**	**3.2**	**3.6**	**3.9**	**4.1**	**4.9**	Artif Bee Colony [8]
avg NEWUOA	88	1036	*97e+0/1e4*	.	.	.	.	.	.	.	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	176	**7.0**	1214	*18e+0/1e5*	.	.	.	.	.	.	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	**20**	342	*59e+0/1e5*	.	.	.	.	.	.	.	Adap DE (F-AUC) [10]
DE (Uniform)	26	362	*66e+0/1e5*	.	.	.	.	.	.	.	DE (Uniform) [9]
IPOP-aCMA-ES	25	**6.3**	**10**	*60e-1/1e5*	.	.	.	.	.	.	IPOP-aCMA-ES [16]
IPOP-CMA-ES	26	**6.3**	13	*50e-1/1e5*	.	.	.	.	.	.	IPOP-CMA-ES [22]
CMA+DE-MOS	**19**	13	**4.7**	**7.4**	**8.9**	**9.4**	**10**	**10**	**11**	**12**	CMA+DE-MOS [18]
NBC-CMA	23	18	839	*18e+0/2e4*	.	.	.	.	.	.	NBC-CMA [21]
POEMS	3775	42	10	64	135	136	140	143	145	151	POEMS [17]
PM-AdapSS-DE	26	137	*56e+0/1e5*	.	.	.	.	.	.	.	PM-AdapSS-DE [9, 10]
pPOEMS	3229	42	13	**57**	**105**	**107**	**109**	**113**	**119**	**132**	pPOEMS [17, 20]
Basic RCGA	**22**	36	27	1867	*41e-1/5e4*	.	.	.	.	.	Basic RCGA [24]
SPSA	1.33e6	*82e+1/1e5*	.	.	.	.	.	.	.	.	SPSA [13]

Table 100: Running time excess ERT/ERT$_{\text{best 2009}}$ on f_4 in **20-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

4 Skew Rastrigin-Bueche separ

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
ERT$_{\text{best}}$/D	0.05	37	236	381	383	384	385	386	388	7053	ERT$_{\text{best}}$/D
(1,2)-CMA-ES	467	*17e+1/1e4*	.	.	.	.	.	.	.	.	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	219	119	*79e+0/1e4*	.	.	.	.	.	.	.	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	200	151	*79e+0/1e4*	.	.	.	.	.	.	.	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	447	*15e+1/1e4*	.	.	.	.	.	.	.	.	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	151	171	*88e+0/1e4*	.	.	.	.	.	.	.	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	100	53	*66e+0/1e4*	.	.	.	.	.	.	.	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	109	66	*69e+0/1e4*	.	.	.	.	.	.	.	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	149	453	*10e+1/1e4*	.	.	.	.	.	.	.	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	**51**	3814	*14e+1/1e4*	.	.	.	.	.	.	.	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	61	3765	*13e+1/1e4*	.	.	.	.	.	.	.	(1+2ms)-CMA-ES [2]
Artif Bee Colony	220	**2.9**	**2.0**	**4.2**	**5.6**	**6.0**	**6.3**	**6.9**	**7.3**	**0.45**	Artif Bee Colony [8]
avg NEWUOA	112	1442	*12e+1/2e4*	.	.	.	.	.	.	.	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	298	**2.5**	*26e+0/1e5*	.	.	.	.	.	.	.	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	93	237	*19e+0/1e5*	.	.	.	.	.	.	.	Adap DE (F-AUC) [10]
DE (Uniform)	109	250	*21e+0/1e5*	.	.	.	.	.	.	.	DE (Uniform) [9]
IPOP-aCMA-ES	**54**	**2.4**	*14e+0/1e5*	.	.	.	.	.	.	.	IPOP-aCMA-ES [16]
IPOP-CMA-ES	59	**2.3**	*13e+0/1e5*	.	.	.	.	.	.	.	IPOP-CMA-ES [22]
CMA+DE-MOS	88	4.7	**10**	**12**	**14**	**14**	**15**	**15**	**16**	**0.93**	CMA+DE-MOS [18]
NBC-CMA	**50**	4.5	*25e+0/1e4*	.	.	.	.	.	.	.	NBC-CMA [21]
POEMS	4010	18	**14**	**109**	**307**	**308**	**310**	**311**	**313**	**18**	POEMS [17]
PM-AdapSS-DE	137	128	*20e+0/1e5*	.	.	.	.	.	.	.	PM-AdapSS-DE [9, 10]
pPOEMS	4614	21	31	254	1043	1054	1056	1056	1054	59	pPOEMS [17, 20]
Basic RCGA	86	67	*22e+0/5e4*	.	.	.	.	.	.	.	Basic RCGA [24]
SPSA	1638	*24e+1/1e5*	.	.	.	.	.	.	.	.	SPSA [13]

Table 101: Running time excess ERT/$\text{ERT}_{\text{best 2009}}$ on f_5 in **20-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

5 Linear slope

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
ERT_{best}/D	0.05	1.8	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	ERT_{best}/D
(1,2)-CMA-ES	**1**	**2.6**	6.1	7.0	7.2	7.2	7.2	7.2	7.2	7.2	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	**1**	**1.6**	3.5	4.4	4.4	4.4	4.4	4.4	4.4	4.4	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	**1**	**1.5**	3.3	3.9	4.1	4.1	4.1	4.1	4.1	4.1	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	**1**	3.1	6.5	7.7	7.9	8.3	8.3	8.3	8.3	8.3	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	**1**	**2.2**	5.1	6.1	6.4	6.5	6.5	6.5	6.5	6.5	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	**1**	**1.9**	3.7	4.4	4.5	4.6	4.6	4.6	4.6	4.6	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	**1**	**1.1**	**2.7**	**3.2**	**3.3**	**3.3**	**3.3**	**3.3**	**3.3**	**3.3**	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	**1**	**1.7**	4.1	5.0	5.4	5.4	5.4	5.4	5.4	5.4	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	**1**	**1.6**	3.1	3.6	3.8	3.8	3.8	3.8	3.8	3.8	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	**1**	**1.1**	**2.5**	**3.1**	**3.2**	**3.2**	**3.2**	**3.2**	**3.2**	**3.2**	(1+2ms)-CMA-ES [2]
Artif Bee Colony	**1**	37	69	90	93	93	93	93	93	93	Artif Bee Colony [8]
avg NEWUOA	**1**	**2.7**	**2.7**	**3.2**	**3.3**	**3.3**	**3.3**	**3.3**	**3.3**	**3.3**	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	**1**	3.6	5.3	5.8	6.0	6.0	6.0	6.0	6.0	6.0	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	**1**	15	42	52	53	54	54	54	54	54	Adap DE (F-AUC) [10]
DE (Uniform)	**1**	27	69	83	85	86	86	86	86	86	DE (Uniform) [9]
IPOP-aCMA-ES	**1**	**2.7**	5.1	6.2	6.2	6.2	6.2	6.2	6.2	6.2	IPOP-aCMA-ES [16]
IPOP-CMA-ES	**1**	3.2	5.8	6.5	6.7	6.7	6.7	6.7	6.7	6.7	IPOP-CMA-ES [22]
CMA+DE-MOS	**1**	23	51	53	53	53	53	53	53	53	CMA+DE-MOS [18]
NBC-CMA	**1**	12	6573	13412	13412	13412	13412	13412	13412	13412	NBC-CMA [21]
POEMS	**1**	180	255	310	330	343	348	350	352	352	POEMS [17]
PM-AdapSS-DE	**1**	35	82	92	96	96	96	96	96	96	PM-AdapSS-DE [9, 10]
pPOEMS	**1**	175	253	308	338	349	355	360	360	360	pPOEMS [17, 20]
Basic RCGA	**1**	138	557	3186	5233	6485	7260	7764	9890	*64e-7/5e4*	Basic RCGA [24]
SPSA	**1**	3.1	6.4	7.9	8.1	8.2	8.2	8.2	8.2	8.2	SPSA [13]

Table 102: Running time excess ERT/$\text{ERT}_{\text{best 2009}}$ on f_6 in **20-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

6 Attractive sector

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
ERT_{best}/D	4.0	26	65	117	171	213	261	298	336	420	ERT_{best}/D
(1,2)-CMA-ES	21	11	8.9	12	26	78	567	*11e-3/1e4*	.	.	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	7.1	3.1	**2.2**	**1.8**	**1.8**	**2.1**	**2.5**	**3.0**	3.5	6.7	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	6.9	**2.7**	**1.9**	**1.6**	**1.5**	**1.5**	**1.7**	**1.8**	**2.1**	3.1	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	19	11	15	41	133	670	*15e-2/1e4*	.	.	.	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	3.8	**2.6**	**2.1**	**1.9**	**2.0**	**2.2**	**2.5**	3.1	3.6	7.4	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	4.6	**2.7**	**2.0**	**1.6**	**1.6**	**1.6**	**1.5**	**1.7**	**1.8**	**2.2**	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	3.2	**1.6**	**1.3**	**1.1**	**1.0**	**1.1**	**1.2**	**1.5**	**1.7**	**2.5**	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	3.3	**2.3**	**2.0**	**2.0**	**2.4**	3.1	4.8	10	22	342	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	**2.1**	**1.7**	13	92	831	*69e-2/1e4*	.	.	.	.	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	**1.7**	**1.8**	12	107	846	*74e-2/1e4*	.	.	.	.	(1+2ms)-CMA-ES [2]
Artif Bee Colony	11	8.3	46	453	2587	*54e-2/1e5*	.	.	.	.	Artif Bee Colony [8]
avg NEWUOA	**2.3**	**1.1**	**1.00**	**0.74**	**0.72**	**0.71**	**0.70**	**0.74**	**0.74**	**0.73**	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	13	5.3	3.7	3.2	3.7	7.5	45	177	874	1036	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	22	25	19	15	14	14	14	14	14	14	Adap DE (F-AUC) [10]
DE (Uniform)	27	40	29	23	20	20	20	20	20	20	DE (Uniform) [9]
IPOP-aCMA-ES	3.6	**2.3**	**1.6**	**1.3**	**1.1**	**1.1**	**1.1**	**1.1**	**1.1**	**1.1**	IPOP-aCMA-ES [16]
IPOP-CMA-ES	3.0	**2.3**	**1.7**	**1.3**	**1.2**	**1.2**	**1.2**	**1.2**	**1.2**	**1.2**	IPOP-CMA-ES [22]
CMA+DE-MOS	20	8.9	5.5	3.9	3.4	3.2	3.0	**3.0**	**3.0**	**2.8**	CMA+DE-MOS [18]
NBC-CMA	53	108	50	28	19	16	13	12	10	8.6	NBC-CMA [21]
POEMS	91	30	32	28	26	26	26	27	27	27	POEMS [17]
PM-AdapSS-DE	22	28	20	16	15	14	14	14	14	14	PM-AdapSS-DE [9, 10]
pPOEMS	94	32	36	32	32	34	34	35	35	38	pPOEMS [17, 20]
Basic RCGA	41	15	52	60	56	54	51	196	2128	*63e-6/5e4*	Basic RCGA [24]
SPSA	2263	*40e+1/1e5*	.	.	.	.	.	.	.	.	SPSA [13]

Table 103: Running time excess ERT/ERT$_{\text{best 2009}}$ on f_7 in **20-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

7 Step-ellipsoid

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
ERT$_{\text{best}}$/D	0.53	7.6	68	214	475	826	826	826	826	848	ERT$_{\text{best}}$/D
(1,2)-CMA-ES	39	42	*23e+0/1e4*	.	.	.	.	.	.	.	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	14	4.4	71	*67e-1/1e4*	.	.	.	.	.	.	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	11	4.8	71	*72e-1/1e4*	.	.	.	.	.	.	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	25	27	*29e+0/1e4*	.	.	.	.	.	.	.	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	4.1	3.7	118	*78e-1/1e4*	.	.	.	.	.	.	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	3.1	3.2	23	*48e-1/1e4*	.	.	.	.	.	.	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	3.0	4.6	37	*62e-1/1e4*	.	.	.	.	.	.	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	3.8	4.5	275	*12e+0/1e4*	.	.	.	.	.	.	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	**3.0**	11	24	41	37	177	177	177	177	172	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	**1.8**	**1.9**	24	54	96	181	181	181	181	176	(1+2ms)-CMA-ES [2]
Artif Bee Colony	5.5	19	251	*60e-1/1e5*	.	.	.	.	.	.	Artif Bee Colony [8]
avg NEWUOA	7.1	**1.4**	101	*51e-1/2e4*	.	.	.	.	.	.	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	21	5.3	21	*53e-1/1e5*	.	.	.	.	.	.	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	3.0	18	5.2	**3.1**	**1.9**	**1.6**	**1.6**	**1.6**	**1.6**	**1.6**	Adap DE (F-AUC) [10]
DE (Uniform)	3.3	30	8.4	5.2	3.3	**2.6**	**2.7**	**2.7**	**2.7**	**2.7**	DE (Uniform) [9]
IPOP-aCMA-ES	**2.7**	**2.5**	**1.6**	**2.7**	**1.6**	**0.99**	**0.99**	**0.99**	**0.99**	**1.0**	IPOP-aCMA-ES [16]
IPOP-CMA-ES	3.1	**3.0**	**1.9**	4.8	**2.7**	**1.7**	**1.7**	**1.7**	**1.7**	**1.6**	IPOP-CMA-ES [22]
CMA+DE-MOS	**2.7**	12	**2.7**	6.0	3.9	**2.4**	**2.4**	**2.4**	**2.4**	**2.3**	CMA+DE-MOS [18]
NBC-CMA	3.2	3.6	**1.3**	31	225	*55e-2/1e4*	.	.	.	.	NBC-CMA [21]
POEMS	429	57	23	1968	*11e-1/3e5*	.	.	.	.	.	POEMS [17]
PM-AdapSS-DE	3.0	21	5.9	**3.4**	**2.1**	**1.6**	**1.6**	**1.6**	**1.6**	**1.7**	PM-AdapSS-DE [9, 10]
pPOEMS	307	55	22	280	1778	2412	2412	2412	2412	2349	pPOEMS [17, 20]
Basic RCGA	4.7	12	13	1111	*13e-1/5e4*	.	.	.	.	.	Basic RCGA [24]
SPSA	104	995	*58e+0/1e5*	.	.	.	.	.	.	.	SPSA [13]

Table 104: Running time excess ERT/$\text{ERT}_{\text{best 2009}}$ on f_8 in **20-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

8 Rosenbrock original

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
ERT_{best}/D	5.5	21	102	194	202	207	211	215	219	224	ERT_{best}/D
(1,2)-CMA-ES	11	4.9	10	19	20	20	20	20	20	20	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	5.4	7.2	5.3	7.8	8.2	8.3	8.3	8.3	8.2	8.1	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	4.5	**2.2**	3.6	4.5	4.8	5.0	5.0	5.0	5.0	5.0	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	11	13	12	17	18	18	19	19	19	18	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	4.1	**2.3**	4.9	7.7	8.0	8.0	8.1	8.0	8.0	8.0	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	3.8	**2.6**	3.6	5.8	6.0	6.1	6.1	6.1	6.1	6.1	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	**2.8**	**2.0**	3.3	5.8	5.9	5.9	5.9	5.9	5.8	5.8	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	4.8	3.2	3.8	5.9	6.2	6.2	6.2	6.2	6.2	6.2	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	**2.6**	**1.5**	**3.2**	4.8	5.1	5.2	5.3	5.3	5.3	5.3	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	**2.4**	**1.7**	**3.0**	5.4	5.6	5.6	5.7	5.7	5.7	5.7	(1+2ms)-CMA-ES [2]
Artif Bee Colony	14	6.4	3.9	5.9	10	37	353	1171	*24e-5/1e5*	.	Artif Bee Colony [8]
avg NEWUOA	**2.0**	**1.6**	**0.96**	**0.97**	**1.0**	**1.0**	**1.0**	**1.0**	**1.0**	**0.99**	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	6.3	3.2	5.3	6.5	6.9	7.1	7.2	7.2	7.3	7.4	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	43	21	23	21	23	24	24	25	25	26	Adap DE (F-AUC) [10]
DE (Uniform)	73	37	34	31	33	34	35	36	37	39	DE (Uniform) [9]
IPOP-aCMA-ES	4.1	**2.6**	3.5	**3.5**	**3.7**	**3.8**	**3.9**	**3.9**	**3.9**	**4.0**	IPOP-aCMA-ES [16]
IPOP-CMA-ES	3.9	3.2	3.7	**3.9**	**4.2**	**4.3**	**4.4**	**4.4**	**4.4**	**4.5**	IPOP-CMA-ES [22]
CMA+DE-MOS	19	6.7	11	12	13	13	13	13	13	13	CMA+DE-MOS [18]
NBC-CMA	5.7	3.5	6.3	6.8	7.7	8.3	8.6	8.7	8.7	8.8	NBC-CMA [21]
POEMS	96	79	500	902	1629	21544	*15e-3/3e5*	.	.	.	POEMS [17]
PM-AdapSS-DE	48	24	35	35	38	39	39	40	40	41	PM-AdapSS-DE [9, 10]
pPOEMS	96	75	103	97	109	117	121	135	147	188	pPOEMS [17, 20]
Basic RCGA	24	25	*17e+0/5e4*	.	.	.	.	.	.	.	Basic RCGA [24]
SPSA	256	3988	*98e+0/1e5*	.	.	.	.	.	.	.	SPSA [13]

Table 105: Running time excess ERT/$\text{ERT}_{\text{best 2009}}$ on f_9 in **20-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

9 Rosenbrock rotated

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
ERT_{best}/D	0.05	18	86	155	164	169	173	176	180	186	ERT_{best}/D
(1,2)-CMA-ES	1227	10	12	24	25	25	25	24	24	24	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	875	6.6	5.8	8.1	8.5	8.6	8.6	8.5	8.5	8.4	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	491	3.1	4.5	6.5	6.8	6.9	6.9	6.9	6.9	6.8	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	1085	11	16	22	23	23	23	23	23	23	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	534	3.7	5.1	6.0	6.5	6.6	6.6	6.6	6.6	6.6	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	421	**2.3**	4.6	5.7	6.1	6.2	6.2	6.2	6.2	6.1	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	284	**2.0**	**3.3**	**5.2**	**5.4**	**5.4**	**5.4**	**5.4**	**5.4**	**5.3**	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	418	**2.7**	5.0	7.2	7.5	7.5	7.5	7.4	7.4	7.3	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	**261**	**1.4**	3.6	6.2	6.4	6.5	6.5	6.5	6.5	6.5	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	**238**	**1.7**	**3.4**	6.9	7.1	7.1	7.1	7.1	7.1	7.0	(1+2ms)-CMA-ES [2]
Artif Bee Colony	1427	10	699	*92e-1/1e5*	.	.	.	.	.	.	Artif Bee Colony [8]
avg NEWUOA	**228**	**1.5**	**1.0**	**1.2**	**1.2**	**1.3**	**1.3**	**1.2**	**1.2**	**1.2**	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	728	5.4	6.6	10	10	10	10	11	11	11	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	3720	21	26	25	27	28	29	30	30	31	Adap DE (F-AUC) [10]
DE (Uniform)	7549	41	41	39	41	42	43	44	45	46	DE (Uniform) [9]
IPOP-aCMA-ES	370	**2.1**	4.1	**4.6**	**4.9**	**5.0**	**5.0**	**5.0**	**5.0**	**5.0**	IPOP-aCMA-ES [16]
IPOP-CMA-ES	378	**2.2**	4.6	5.7	6.0	6.1	6.1	6.1	6.1	6.1	IPOP-CMA-ES [22]
CMA+DE-MOS	1526	5.2	10	12	15	15	15	15	15	15	CMA+DE-MOS [18]
NBC-CMA	610	**2.9**	7.1	9.1	10	11	11	11	11	11	NBC-CMA [21]
POEMS	10487	164	1097	*22e-1/3e5*	.	.	.	.	.	.	POEMS [17]
PM-AdapSS-DE	4649	25	37	41	43	45	45	46	46	47	PM-AdapSS-DE [9, 10]
pPOEMS	9902	86	214	328	443	680	972	1281	2537	24109	pPOEMS [17, 20]
Basic RCGA	678	17	*17e+0/5e4*	.	.	.	.	.	.	.	Basic RCGA [24]
SPSA	59214	16242	*14e+1/1e5*	.	.	.	.	.	.	.	SPSA [13]

Table 106: Running time excess $\mathrm{ERT}/\mathrm{ERT}_{\text{best 2009}}$ on f_{10} in **20-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

10 Ellipsoid

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
$\mathrm{ERT}_{\text{best}}/D$	116	263	371	433	537	682	746	810	854	874	$\mathrm{ERT}_{\text{best}}/D$
(1,2)-CMA-ES	13	9.1	7.9	7.4	6.4	5.2	4.9	4.5	4.4	4.3	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	6.8	4.2	3.5	3.5	**2.9**	**2.4**	**2.2**	**2.1**	**2.0**	**2.0**	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	5.5	3.8	3.2	**3.0**	**2.5**	**2.0**	**1.8**	**1.7**	**1.6**	**1.6**	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	16	11	9.0	8.2	6.9	5.5	5.1	4.8	4.6	4.6	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	4.2	3.1	**2.8**	**2.8**	**2.4**	**1.9**	**1.8**	**1.6**	**1.6**	**1.6**	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	3.5	**2.6**	**2.3**	**2.2**	**1.9**	**1.6**	**1.5**	**1.4**	**1.3**	**1.3**	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	**3.0**	**2.0**	**1.8**	**1.7**	**1.5**	**1.2**	**1.1**	**1.0**	**0.98**	**0.98**	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	3.4	**2.6**	**2.4**	**2.3**	**2.0**	**1.6**	**1.5**	**1.4**	**1.3**	**1.3**	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	**2.3**	**1.8**	**1.7**	**1.7**	**1.4**	**1.2**	**1.1**	**1.0**	**0.99**	**0.99**	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	**1.6**	**1.3**	**1.3**	**1.3**	**1.2**	**0.98**	**0.91**	**0.85**	**0.82**	**0.82**	(1+2ms)-CMA-ES [2]
Artif Bee Colony	*50e+2/1e5*	.	.	.	.	.	.	.	.	.	Artif Bee Colony [8]
avg NEWUOA	**0.81**	**1.0**	**1.5**	**2.6**	3.1	3.1	3.6	3.9	4.2	5.0	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	7.8	4.6	3.9	3.5	**2.9**	**2.3**	**2.2**	**2.0**	**1.9**	**1.9**	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	4.3	**2.7**	**2.5**	**2.6**	**2.4**	**2.2**	**2.2**	**2.3**	**2.4**	**2.8**	Adap DE (F-AUC) [10]
DE (Uniform)	7.1	4.3	3.9	4.1	3.9	3.5	3.6	3.8	3.9	4.6	DE (Uniform) [9]
IPOP-aCMA-ES	**1.7**	**1.2**	**1.2**	**1.2**	**1.0**	**0.85**	**0.80**	**0.75**	**0.73**	**0.75**	IPOP-aCMA-ES [16]
IPOP-CMA-ES	**2.3**	**1.7**	**1.8**	**1.8**	**1.5**	**1.3**	**1.2**	**1.1**	**1.1**	**1.1**	IPOP-CMA-ES [22]
CMA+DE-MOS	4.9	3.4	3.4	3.4	**3.0**	**2.5**	**2.3**	**2.2**	**2.1**	**2.2**	CMA+DE-MOS [18]
NBC-CMA	4.1	**2.9**	3.1	3.3	3.0	**2.6**	**2.5**	**2.4**	**2.3**	**2.3**	NBC-CMA [21]
POEMS	1036	*35e+1/3e5*	.	.	.	.	.	.	.	.	POEMS [17]
PM-AdapSS-DE	5.1	3.0	**2.7**	**2.8**	**2.6**	**2.4**	**2.4**	**2.5**	**2.6**	**3.0**	PM-AdapSS-DE [9, 10]
pPOEMS	183	1311	*97e+0/3e5*	.	.	.	.	.	.	.	pPOEMS [17, 20]
Basic RCGA	*48e+2/5e4*	.	.	.	.	.	.	.	.	.	Basic RCGA [24]
SPSA	*30e+2/1e5*	.	.	.	.	.	.	.	.	.	SPSA [13]

Table 107: Running time excess ERT/ERT$_{\text{best 2009}}$ on f_{11} in **20-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

11 Discus

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
ERT$_{\text{best}}$/D	1.4	24	50	111	314	429	488	554	614	742	ERT$_{\text{best}}$/D
(1,2)-CMA-ES	481	44	24	12	4.8	3.8	3.6	3.4	3.2	**2.9**	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	359	33	18	8.6	3.3	**2.5**	**2.3**	**2.1**	**2.0**	**1.7**	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	347	29	16	7.7	**2.9**	**2.2**	**2.0**	**1.8**	**1.7**	**1.5**	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	514	40	22	12	4.5	3.7	3.5	3.3	3.2	**2.9**	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	233	29	16	8.0	3.1	**2.4**	**2.2**	**2.0**	**1.9**	**1.6**	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	139	29	16	7.8	**2.9**	**2.3**	**2.1**	**1.9**	**1.8**	**1.5**	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	197	23	13	6.1	**2.3**	**1.8**	**1.6**	**1.5**	**1.4**	**1.2**	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	126	22	13	6.3	**2.4**	**1.9**	**1.8**	**1.6**	**1.5**	**1.3**	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	**3.1**	**6.9**	7.7	5.9	**2.7**	**2.6**	**2.6**	**2.5**	**2.4**	**2.1**	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	6.9	**4.8**	**5.8**	**4.3**	**2.1**	**1.9**	**2.0**	**2.0**	**1.9**	**1.7**	(1+2ms)-CMA-ES [2]
Artif Bee Colony	**2.0**	2180	*92e+0/1e5*	.	.	.	.	.	.	.	Artif Bee Colony [8]
avg NEWUOA	6.0	11	15	11	5.7	5.1	5.6	5.5	5.8	6.1	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	912	135	119	94	58	60	54	48	45	50	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	7.7	**7.7**	**7.3**	**5.1**	**2.4**	**2.2**	**2.3**	**2.3**	**2.4**	**2.5**	Adap DE (F-AUC) [10]
DE (Uniform)	5.0	11	11	8.1	3.8	3.5	3.8	3.9	4.0	4.2	DE (Uniform) [9]
IPOP-aCMA-ES	13	7.9	**4.5**	**2.3**	**0.87**	**0.68**	**0.64**	**0.59**	**0.56**	**0.50**	IPOP-aCMA-ES [16]
IPOP-CMA-ES	**2.5**	19	11	5.4	**2.1**	**1.6**	**1.4**	**1.3**	**1.2**	**1.1**	IPOP-CMA-ES [22]
CMA+DE-MOS	4.0	15	21	10	4.0	3.1	**2.9**	**2.6**	**2.5**	**2.2**	CMA+DE-MOS [18]
NBC-CMA	4.3	203	*85e+0/1e4*	.	.	.	.	.	.	.	NBC-CMA [21]
POEMS	126	51	483	400	218	207	220	230	240	258	POEMS [17]
PM-AdapSS-DE	8.6	10	8.7	5.7	**2.6**	**2.4**	**2.5**	**2.6**	**2.6**	**2.7**	PM-AdapSS-DE [9, 10]
pPOEMS	132	52	111	106	84	142	358	1006	7059	*18e-5/3e5*	pPOEMS [17, 20]
Basic RCGA	4.8	40	*51e+0/5e4*	.	.	.	.	.	.	.	Basic RCGA [24]
SPSA	74845	*97e+1/1e5*	.	.	.	.	.	.	.	.	SPSA [13]

Table 108: Running time excess ERT/$\text{ERT}_{\text{best 2009}}$ on f_{12} in **20-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

12 Bent cigar

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
ERT_{best}/D	25	30	52	97	137	158	207	321	620	691	ERT_{best}/D
(1,2)-CMA-ES	5.9	19	24	21	19	19	16	11	6.4	6.7	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	**3.0**	8.8	15	13	12	11	9.3	6.5	3.6	3.6	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	**2.4**	3.7	7.4	8.0	7.6	7.5	6.4	4.6	**2.6**	**2.6**	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	5.3	10	23	23	21	21	18	13	7.0	7.5	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	**2.7**	5.3	8.8	8.8	8.5	8.5	7.2	5.1	**2.9**	**2.9**	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	**2.3**	3.6	6.1	6.7	6.5	6.7	5.7	4.1	**2.3**	**2.3**	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	**1.7**	3.1	**4.8**	**5.1**	**5.0**	**5.1**	**4.4**	**3.1**	**1.8**	**1.8**	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	**2.2**	3.7	7.1	6.9	6.7	6.7	5.7	4.1	**2.3**	**2.3**	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	**1.9**	**2.5**	6.6	10	10	11	9.1	6.4	3.6	3.7	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	**1.7**	**2.3**	6.3	8.3	8.2	8.3	6.9	4.9	**2.9**	3.1	(1+2ms)-CMA-ES [2]
Artif Bee Colony	13	21	26	67	429	2185	7243	*18e-3/1e5*	.	.	Artif Bee Colony [8]
avg NEWUOA	**1.4**	**1.3**	11	15	18	24	24	20	12	21	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	4.3	16	30	37	39	39	33	23	13	14	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	37	38	27	20	19	21	20	16	9.4	10	Adap DE (F-AUC) [10]
DE (Uniform)	63	65	44	27	25	27	26	21	12	13	DE (Uniform) [9]
IPOP-aCMA-ES	**2.9**	**3.0**	**2.6**	**3.0**	**3.2**	**3.4**	**3.1**	**2.3**	**1.3**	**1.4**	IPOP-aCMA-ES [16]
IPOP-CMA-ES	**2.9**	3.1	**4.8**	**5.3**	**5.5**	**5.9**	**5.1**	**3.8**	**2.1**	**2.2**	IPOP-CMA-ES [22]
CMA+DE-MOS	10	10	7.1	8.9	14	14	12	8.5	4.7	4.7	CMA+DE-MOS [18]
NBC-CMA	4.0	4.0	6.2	13	14	15	13	9.1	5.2	5.2	NBC-CMA [21]
POEMS	155	171	1557	4721	*12e-1/3e5*	.	.	.	.	.	POEMS [17]
PM-AdapSS-DE	43	43	29	18	20	24	24	20	12	13	PM-AdapSS-DE [9, 10]
pPOEMS	5132	4450	3375	3894	9258	*17e-1/3e5*	.	.	.	.	pPOEMS [17, 20]
Basic RCGA	329	343	222	241	519	1359	*12e-2/5e4*	.	.	.	Basic RCGA [24]
SPSA	8176	9420	*20e+5/1e5*	.	.	.	.	.	.	.	SPSA [13]

Table 109: Running time excess ERT/ERT$_{\text{best 2009}}$ on f_{13} in **20-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

13 Sharp ridge

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
ERT$_{\text{best}}$/D	3.2	8.5	33	101	138	175	937	1086	1223	1510	ERT$_{\text{best}}$/D
(1,2)-CMA-ES	11	10	20	25	41	87	47	63	*13e-3/1e4*	.	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	4.8	5.2	13	12	24	36	33	62	55	93	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	4.5	4.7	4.6	6.9	23	37	49	130	116	94	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	10	9.5	13	29	41	115	36	*27e-3/1e4*	.	.	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	4.2	5.0	8.3	15	25	42	21	65	121	*46e-4/1e4*	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	3.4	4.0	6.4	10	16	28	8.0	18	36	*32e-5/1e4*	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	**2.6**	**3.2**	**4.5**	6.6	11	26	21	30	56	*18e-4/1e4*	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	3.5	4.0	7.6	4.9	14	23	17	30	57	*10e-4/1e4*	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	**2.5**	3.3	6.5	**4.8**	10	16	4.1	5.4	7.6	13	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	**2.3**	**3.0**	4.9	6.0	**7.7**	13	3.3	3.6	5.2	18	(1+2ms)-CMA-ES [2]
Artif Bee Colony	25	41	25	73	627	3931	1555	*60e-3/1e5*	.	.	Artif Bee Colony [8]
avg NEWUOA	**2.1**	**1.8**	**1.5**	5.3	14	30	14	57	172	*67e-5/2e4*	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	6.4	6.5	6.8	7.6	37	125	108	256	556	*90e-5/1e5*	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	35	55	25	12	11	**11**	**2.4**	**2.4**	**2.5**	**2.5**	Adap DE (F-AUC) [10]
DE (Uniform)	57	90	43	20	19	19	4.1	4.1	4.2	4.2	DE (Uniform) [9]
IPOP-aCMA-ES	3.9	5.3	**3.6**	**3.4**	**3.7**	**3.4**	**0.80**	**0.98**	**1.3**	**1.3**	IPOP-aCMA-ES [16]
IPOP-CMA-ES	3.5	5.3	6.5	**4.8**	**6.2**	**5.1**	**1.4**	**1.6**	**1.7**	**2.3**	IPOP-CMA-ES [22]
CMA+DE-MOS	16	18	10	9.1	12	12	**2.8**	**2.9**	3.2	3.0	CMA+DE-MOS [18]
NBC-CMA	6.0	7.6	4.7	15	29	24	5.7	7.4	9.3	45	NBC-CMA [21]
POEMS	98	201	6277	41616	*90e-1/3e5*	.	.	.	.	.	POEMS [17]
PM-AdapSS-DE	41	63	28	13	12	12	**2.6**	**2.6**	**2.6**	**2.6**	PM-AdapSS-DE [9, 10]
pPOEMS	104	223	938	2244	6207	24363	4562	*57e-2/3e5*	.	.	pPOEMS [17, 20]
Basic RCGA	19	112	232	296	825	1228	*28e-2/5e4*	.	.	.	Basic RCGA [24]
SPSA	76	2892	*29e+0/1e5*	.	.	.	.	.	.	.	SPSA [13]

Table 110: Running time excess $\mathrm{ERT}/\mathrm{ERT}_{\text{best 2009}}$ on f_{14} in **20-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

14 Sum of different powers

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
$\mathrm{ERT}_{\text{best}}$/D	0.05	0.05	3.8	12	15	23	47	67	82	783	$\mathrm{ERT}_{\text{best}}$/D
(1,2)-CMA-ES	**1**	156	16	8.2	8.2	8.2	7.8	10	14	4.8	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	**1**	62	7.7	3.8	4.1	4.2	4.2	5.6	8.1	**2.0**	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	**1**	41	6.0	3.1	3.3	3.5	3.6	4.9	6.6	**1.6**	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	**1**	143	14	6.9	7.4	7.4	6.9	9.3	13	5.7	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	**1**	16	5.7	3.1	3.6	4.0	3.9	5.2	7.3	**1.6**	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	**1**	19	5.0	**2.8**	3.1	3.3	3.2	4.5	6.4	**1.4**	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	**1**	16	3.8	**2.1**	**2.3**	**2.6**	**2.6**	3.5	**5.0**	**1.1**	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	**1**	17	4.7	**2.6**	**2.9**	3.4	3.2	4.2	5.4	**1.3**	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	**1**	12	**2.9**	**1.9**	**2.3**	**2.5**	**2.2**	**3.3**	5.4	**1.2**	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	**1**	13	**2.3**	**1.6**	**1.9**	**2.1**	**1.9**	**2.7**	**4.5**	**0.97**	(1+2ms)-CMA-ES [2]
Artif Bee Colony	**1.1**	**4.0**	18	18	28	53	3378	*10e-4/1e5*	.	.	Artif Bee Colony [8]
avg NEWUOA	**1**	38	**2.7**	**1.5**	**1.6**	**1.6**	**1.3**	**2.7**	9.3	26	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	26	159	10	4.6	5.2	5.7	6.2	11	22	4.8	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	**1**	**4.5**	33	30	38	36	23	20	19	**2.8**	Adap DE (F-AUC) [10]
DE (Uniform)	**1**	5.5	53	50	64	60	38	32	31	4.2	DE (Uniform) [9]
IPOP-aCMA-ES	**1**	10	3.6	**2.7**	3.5	4.0	3.2	3.4	**3.9**	**0.67**	IPOP-aCMA-ES [16]
IPOP-CMA-ES	**1**	13	3.7	**2.8**	3.6	4.2	3.9	4.7	6.0	**1.2**	IPOP-CMA-ES [22]
CMA+DE-MOS	**1**	5.1	20	10	11	13	12	13	14	**2.3**	CMA+DE-MOS [18]
NBC-CMA	**1.1**	**3.5**	5.5	3.7	4.6	5.3	5.1	6.9	9.0	**1.7**	NBC-CMA [21]
POEMS	**1**	3152	98	65	123	165	131	1158	*27e-6/3e5*	.	POEMS [17]
PM-AdapSS-DE	**1**	5.1	43	34	43	40	25	21	20	**2.8**	PM-AdapSS-DE [9, 10]
pPOEMS	**1**	743	102	72	143	423	353	443	4529	*78e-7/3e5*	pPOEMS [17, 20]
Basic RCGA	**1**	4.9	16	26	57	298	1502	*11e-4/5e4*	.	.	Basic RCGA [24]
SPSA	59	853	98	51	45	39	56	234	1207	*85e-7/1e5*	SPSA [13]

Table 111: Running time excess ERT/$\text{ERT}_{\text{best 2009}}$ on f_{15} in **20-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

15 Rastrigin

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
ERT_{best}/D	0.06	84	1519	7327	15577	15779	15996	16135	22471	22954	ERT_{best}/D
(1,2)-CMA-ES	227	536	*15e+1/1e4*	.	.	.	.	.	.	.	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	114	13	*55e+0/1e4*	.	.	.	.	.	.	.	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	78	13	*54e+0/1e4*	.	.	.	.	.	.	.	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	258	1748	*15e+1/1e4*	.	.	.	.	.	.	.	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	43	24	*65e+0/1e4*	.	.	.	.	.	.	.	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	28	8.5	*50e+0/1e4*	.	.	.	.	.	.	.	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	30	6.2	*53e+0/1e4*	.	.	.	.	.	.	.	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	58	27	*76e+0/1e4*	.	.	.	.	.	.	.	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	24	75	*83e+0/1e4*	.	.	.	.	.	.	.	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	20	52	*81e+0/1e4*	.	.	.	.	.	.	.	(1+2ms)-CMA-ES [2]
Artif Bee Colony	70	582	*84e+0/1e5*	.	.	.	.	.	.	.	Artif Bee Colony [8]
avg NEWUOA	56	116	*95e+0/1e4*	.	.	.	.	.	.	.	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	188	**1.3**	280	*14e+0/1e5*	.	.	.	.	.	.	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	18	43	474	*30e+0/1e5*	.	.	.	.	.	.	Adap DE (F-AUC) [10]
DE (Uniform)	**12**	55	979	*38e+0/1e5*	.	.	.	.	.	.	DE (Uniform) [9]
IPOP-aCMA-ES	20	**1.3**	**0.82**	**1.1**	**0.71**	**0.72**	**0.72**	**0.73**	**0.53**	**0.54**	IPOP-aCMA-ES [16]
IPOP-CMA-ES	25	**1.3**	**1.1**	**1.1**	**0.69**	**0.70**	**0.70**	**0.71**	**0.52**	**0.53**	IPOP-CMA-ES [22]
CMA+DE-MOS	35	**2.9**	**1.5**	**1.6**	**0.98**	**0.98**	**0.99**	**1.00**	**0.73**	**0.73**	CMA+DE-MOS [18]
NBC-CMA	21	17	*20e+0/1e4*	.	.	.	.	.	.	.	NBC-CMA [21]
POEMS	2565	21	*33e+0/3e5*	.	.	.	.	.	.	.	POEMS [17]
PM-AdapSS-DE	**16**	19	*59e+0/1e5*	.	.	.	.	.	.	.	PM-AdapSS-DE [9, 10]
pPOEMS	1958	69	*20e+0/3e5*	.	.	.	.	.	.	.	pPOEMS [17, 20]
Basic RCGA	**13**	14	6.3	97	*50e-1/5e4*	.	.	.	.	.	Basic RCGA [24]
SPSA	8.91e5	16866	*16e+1/1e5*	.	.	.	.	.	.	.	SPSA [13]

Table 112: Running time excess ERT/$\text{ERT}_{\text{best 2009}}$ on f_{16} in **20-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

16 Weierstrass

Δftarget ERT_{best}/D	1e+03 0.05	1e+02 0.05	1e+01 69	1e+00 1363	1e-01 3851	1e-02 6963	1e-03 9397	1e-04 9762	1e-05 9889	1e-07 11005	Δftarget ERT_{best}/D
(1,2)-CMA-ES	**1**	**1.1**	*31e+0/1e4*	.	.	.	.	.	.	.	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	**1**	**1.3**	153	*94e-1/1e4*	.	.	.	.	.	.	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	**1**	**1.5**	191	*97e-1/1e4*	.	.	.	.	.	.	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	**1**	**1**	*33e+0/1e4*	.	.	.	.	.	.	.	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	**1**	**1.1**	141	*88e-1/1e4*	.	.	.	.	.	.	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	**1**	**1.3**	34	*61e-1/1e4*	.	.	.	.	.	.	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	**1**	**1.4**	49	*55e-1/1e4*	.	.	.	.	.	.	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	**1**	**1.3**	124	*86e-1/1e4*	.	.	.	.	.	.	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	**1**	**1.2**	31	*57e-1/1e4*	.	.	.	.	.	.	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	**1**	**1.3**	15	*51e-1/1e4*	.	.	.	.	.	.	(1+2ms)-CMA-ES [2]
Artif Bee Colony	**1**	**1.4**	13	*39e-1/1e5*	.	.	.	.	.	.	Artif Bee Colony [8]
avg NEWUOA	**1**	**1.5**	3.6	*31e-1/2e4*	.	.	.	.	.	.	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	**1**	88	4.6	41	179	*55e-2/1e5*	.	.	.	.	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	**1**	**1.2**	*15e+0/1e5*	.	.	.	.	.	.	.	Adap DE (F-AUC) [10]
DE (Uniform)	**1**	**1.1**	21496	*15e+0/1e5*	.	.	.	.	.	.	DE (Uniform) [9]
IPOP-aCMA-ES	**1**	**1.5**	**2.8**	**1.1**	**0.88**	**0.76**	**0.80**	**0.81**	**0.82**	**0.76**	IPOP-aCMA-ES [16]
IPOP-CMA-ES	**1**	**1.2**	**1.7**	**0.81**	**0.92**	**0.85**	**0.84**	**0.94**	**1.1**	**1.0**	IPOP-CMA-ES [22]
CMA+DE-MOS	**1**	**1.1**	**1.8**	**0.27**	**0.50**	**2.9**	**5.5**	**5.6**	**5.6**	**6.3**	CMA+DE-MOS [18]
NBC-CMA	**1**	**1.1**	19	**1.8**	7.1	*15e-2/1e4*	.	.	.	.	NBC-CMA [21]
POEMS	**1**	69	14	**2.6**	508	*33e-2/3e5*	.	.	.	.	POEMS [17]
PM-AdapSS-DE	**1**	**1.3**	21677	*14e+0/1e5*	.	.	.	.	.	.	PM-AdapSS-DE [9, 10]
pPOEMS	**1**	**1.3**	26	24	1098	*29e-2/3e5*	.	.	.	.	pPOEMS [17, 20]
Basic RCGA	**1**	**1.1**	8.1	4.6	18	102	*12e-2/5e4*	.	.	.	Basic RCGA [24]
SPSA	**1**	8885	4463	*13e+0/1e5*	.	.	.	.	.	.	SPSA [13]

Table 113: Running time excess ERT/$\text{ERT}_{\text{best 2009}}$ on f_{17} in **20-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

17 Schaffer F7, condition 10

Δftarget ERT_{best}/D	1e+03 0.05	1e+02 0.05	1e+01 3.1	1e+00 52	1e-01 200	1e-02 612	1e-03 1534	1e-04 2231	1e-05 2814	1e-07 4024	Δftarget ERT_{best}/D
(1,2)-CMA-ES	**1**	**1**	403	*53e-1/1e4*	.	.	.	.	.	.	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	**1**	13	8.6	2765	*19e-1/1e4*	.	.	.	.	.	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	**1**	10	6.7	2880	*20e-1/1e4*	.	.	.	.	.	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	**1**	15	462	*64e-1/1e4*	.	.	.	.	.	.	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	**1**	**1**	73	2771	*26e-1/1e4*	.	.	.	.	.	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	**1**	**1.1**	5.1	641	*22e-1/1e4*	.	.	.	.	.	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	**1**	7.1	6.1	1374	*16e-1/1e4*	.	.	.	.	.	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	**1**	3.3	59	*30e-1/1e4*	.	.	.	.	.	.	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	**1**	**1.3**	53	*48e-1/1e4*	.	.	.	.	.	.	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	**1**	**1.2**	42	*46e-1/1e4*	.	.	.	.	.	.	(1+2ms)-CMA-ES [2]
Artif Bee Colony	**1**	**1.1**	34	*40e-1/1e5*	.	.	.	.	.	.	Artif Bee Colony [8]
avg NEWUOA	**1**	**2.1**	**2.4**	*29e-1/4e4*	.	.	.	.	.	.	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	72	141	7.2	**1.2**	**1.1**	**1.2**	**1.1**	**2.1**	3.8	12	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	**1**	**1.4**	23	13	6.6	3.4	**1.9**	**1.7**	**1.9**	5.5	Adap DE (F-AUC) [10]
DE (Uniform)	**1**	**1.3**	38	19	10	5.4	3.0	**2.8**	3.2	**2.8**	DE (Uniform) [9]
IPOP-aCMA-ES	**1**	**1.3**	**2.3**	**0.89**	**0.50**	**1.3**	**0.82**	**0.71**	**0.83**	**0.87**	IPOP-aCMA-ES [16]
IPOP-CMA-ES	**1**	**1**	**2.1**	**0.94**	**1.2**	**1.0**	**0.76**	**0.91**	**0.99**	**1.0**	IPOP-CMA-ES [22]
CMA+DE-MOS	**1**	**1.1**	11	8.2	**2.8**	**1.5**	**1.1**	**1.0**	**1.2**	**1.0**	CMA+DE-MOS [18]
NBC-CMA	**1**	**1.1**	3.4	**1.2**	**1.1**	**1.3**	15	*10e-4/2e4*	.	.	NBC-CMA [21]
POEMS	**1**	691	98	27	126	188	299	1887	*21e-4/3e5*	.	POEMS [17]
PM-AdapSS-DE	**1**	**1.4**	23	13	6.6	3.4	**1.9**	**1.7**	**1.8**	18	PM-AdapSS-DE [9, 10]
pPOEMS	**1**	**1.3**	98	31	54	115	313	1911	*11e-4/3e5*	.	pPOEMS [17, 20]
Basic RCGA	**1.1**	**1.5**	6.1	13	31	23	17	32	*12e-5/5e4*	.	Basic RCGA [24]
SPSA	3.00e6	3.00e6	87351	*23e+2/1e5*	.	.	.	.	.	.	SPSA [13]

Table 114: Running time excess ERT/$\text{ERT}_{\text{best 2009}}$ on f_{18} in **20-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

18 Schaffer F7, condition 1000

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
ERT_{best}/D	0.05	0.14	31	199	978	1428	3378	4977	6530	7326	ERT_{best}/D
(1,2)-CMA-ES	**1.1**	103	*18e+0/1e4*	.	.	.	.	.	.	.	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	**1**	45	143	*64e-1/1e4*	.	.	.	.	.	.	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	**1.1**	31	131	*73e-1/1e4*	.	.	.	.	.	.	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	6.4	115	*19e+0/1e4*	.	.	.	.	.	.	.	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	**1**	16	257	*82e-1/1e4*	.	.	.	.	.	.	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	**1.1**	10	67	*40e-1/1e4*	.	.	.	.	.	.	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	**1**	11	34	*54e-1/1e4*	.	.	.	.	.	.	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	**1**	20	302	*91e-1/1e4*	.	.	.	.	.	.	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	**1**	10	*15e+0/1e4*	.	.	.	.	.	.	.	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	**1**	**3.7**	4700	*14e+0/1e4*	.	.	.	.	.	.	(1+2ms)-CMA-ES [2]
Artif Bee Colony	**1.1**	21	45792	*13e+0/1e5*	.	.	.	.	.	.	Artif Bee Colony [8]
avg NEWUOA	**1.3**	19	3217	*10e+0/6e4*	.	.	.	.	.	.	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	74	64	**1.4**	**0.97**	**1.1**	**2.0**	**2.2**	10	31	201	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	**1.1**	5.7	11	4.6	**1.7**	**1.8**	3.2	6.0	11	28	Adap DE (F-AUC) [10]
DE (Uniform)	**1**	6.4	18	7.8	**2.8**	**2.9**	**1.7**	**1.5**	**1.5**	**1.6**	DE (Uniform) [9]
IPOP-aCMA-ES	**1.3**	7.5	**1.2**	**1.5**	**0.75**	**1.1**	**0.91**	**0.86**	**0.78**	**0.83**	IPOP-aCMA-ES [16]
IPOP-CMA-ES	**1**	7.2	**1.1**	**1.8**	**1.1**	**1.5**	**0.97**	**1.2**	**1.0**	**1.1**	IPOP-CMA-ES [22]
CMA+DE-MOS	**1.1**	4.9	4.0	**1.6**	**1.1**	**1.8**	**1.3**	**1.3**	**1.3**	**1.2**	CMA+DE-MOS [18]
NBC-CMA	**1.1**	**3.1**	**1.5**	**0.76**	**1.1**	35	*16e-3/2e4*	.	.	.	NBC-CMA [21]
POEMS	**2.4**	915	21	125	275	2948	*92e-3/3e5*	.	.	.	POEMS [17]
PM-AdapSS-DE	**1**	**4.4**	13	5.4	**1.9**	**1.9**	8.4	5.9	6.5	7.8	PM-AdapSS-DE [9, 10]
pPOEMS	**1.1**	487	21	51	106	1394	*33e-3/3e5*	.	.	.	pPOEMS [17, 20]
Basic RCGA	**1**	6.7	7.5	20	23	62	*16e-3/5e4*	.	.	.	Basic RCGA [24]
SPSA	5.50e6	2.86e6	*46e+2/1e5*	.	.	.	.	.	.	.	SPSA [13]

Table 115: Running time excess ERT/ERT$_{\text{best 2009}}$ on f_{19} in **20-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

19 Griewank-Rosenbrock F8F2

Δftarget ERT$_{\text{best}}$/D	1e+03 0.05	1e+02 0.05	1e+01 0.05	1e+00 0.05	1e-01 17160	1e-02 2.34e5	1e-03 3.11e5	1e-04 3.33e5	1e-05 3.34e5	1e-07 3.37e5	Δftarget ERT$_{\text{best}}$/D
(1,2)-CMA-ES	**1**	**1**	2312	*62e-1/1e4*	.	.	.	.	.	.	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	**1**	**1**	657	*27e-1/1e4*	.	.	.	.	.	.	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	**1**	**1**	409	*31e-1/1e4*	.	.	.	.	.	.	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	**1**	**1**	3531	*66e-1/1e4*	.	.	.	.	.	.	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	**1**	**1**	440	*24e-1/1e4*	.	.	.	.	.	.	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	**1**	**1**	256	1.42e6	*19e-1/1e4*	.	.	.	.	.	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	**1**	**1**	226	2.84e6	*16e-1/1e4*	.	.	.	.	.	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	**1**	**1**	334	2.82e6	*36e-1/1e4*	.	.	.	.	.	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	**1**	**1**	289	2.94e6	*18e-1/1e4*	.	.	.	.	.	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	**1**	**1**	851	*16e-1/1e4*	.	.	.	.	.	.	(1+2ms)-CMA-ES [2]
Artif Bee Colony	**1**	**1**	2292	*37e-1/1e5*	.	.	.	.	.	.	Artif Bee Colony [8]
avg NEWUOA	**1**	**2.9**	**210**	8.03e6	*20e-1/1e5*	.	.	.	.	.	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	37	118	412	44147	*33e-2/1e5*	.	.	.	.	.	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	**1**	**1.2**	1315	9.54e6	*31e-1/1e5*	.	.	.	.	.	Adap DE (F-AUC) [10]
DE (Uniform)	**1**	**1.1**	2846	9.50e6	*29e-1/1e5*	.	.	.	.	.	DE (Uniform) [9]
IPOP-aCMA-ES	**1**	**1**	**166**	**29179**	**0.63**	**0.46**	**0.43**	**0.43**	**0.44**	**0.44**	IPOP-aCMA-ES [16]
IPOP-CMA-ES	**1**	**1**	**161**	**27333**	**0.71**	**0.45**	**0.38**	**0.41**	**0.41**	**0.41**	IPOP-CMA-ES [22]
CMA+DE-MOS	**1**	**1.1**	1233	**20554**	**2.9**	**3.2**	*47e-3/1e5*	.	.	.	CMA+DE-MOS [18]
NBC-CMA	**1**	**1.1**	255	*41e-1/2e4*	.	.	.	.	.	.	NBC-CMA [21]
POEMS	**1**	701	6058	6.15e6	*98e-2/3e5*	.	.	.	.	.	POEMS [17]
PM-AdapSS-DE	**1**	**1.1**	1839	*26e-1/1e5*	.	.	.	.	.	.	PM-AdapSS-DE [9, 10]
pPOEMS	**1**	**1.2**	6256	1.44e6	*45e-2/3e5*	.	.	.	.	.	pPOEMS [17, 20]
Basic RCGA	**1**	**1.2**	311	4.06e5	6.9	*23e-2/5e4*	.	.	.	.	Basic RCGA [24]
SPSA	116	413	5211	*39e-1/1e5*	.	.	.	.	.	.	SPSA [13]

Table 116: Running time excess ERT/ERT$_{\text{best 2009}}$ on f_{20} in **20-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

20 Schwefel x*sin(x)

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
ERT$_{\text{best}}$/D	2.8	3.5	4.1	2307	1.55e5	2.76e5	2.77e5	2.78e5	2.80e5	2.82e5	ERT$_{\text{best}}$/D
(1,2)-CMA-ES	15	13	13	30	*12e-1/1e4*	.	.	.	.	.	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	7.5	6.9	6.5	30	*11e-1/1e4*	.	.	.	.	.	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	6.0	5.6	5.3	*11e-1/1e4*	.	.	.	.	.	.	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	14	12	11	15	*12e-1/1e4*	.	.	.	.	.	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	5.9	5.6	5.1	61	*12e-1/1e4*	.	.	.	.	.	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	5.0	4.6	4.6	31	*11e-1/1e4*	.	.	.	.	.	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	3.8	3.6	3.5	11	*11e-1/1e4*	.	.	.	.	.	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	4.7	4.4	4.4	7.3	*10e-1/1e4*	.	.	.	.	.	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	**3.5**	**3.5**	**3.3**	20	*12e-1/1e4*	.	.	.	.	.	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	**3.2**	**3.1**	**2.9**	18	*11e-1/1e4*	.	.	.	.	.	(1+2ms)-CMA-ES [2]
Artif Bee Colony	20	18	16	**0.12**	*23e-2/1e5*	.	.	.	.	.	Artif Bee Colony [8]
avg NEWUOA	**1.8**	**1.4**	**1.3**	107	*12e-1/2e4*	.	.	.	.	.	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	10	8.7	7.9	*20e-1/1e5*	.	.	.	.	.	.	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	43	42	40	643	*15e-1/1e5*	.	.	.	.	.	Adap DE (F-AUC) [10]
DE (Uniform)	76	77	76	*17e-1/1e5*	.	.	.	.	.	.	DE (Uniform) [9]
IPOP-aCMA-ES	4.5	4.7	4.7	3.2	**0.83**	**0.58**	**0.58**	**0.59**	**0.59**	**0.60**	IPOP-aCMA-ES [16]
IPOP-CMA-ES	4.9	4.8	4.6	6.4	**0.65**	**0.57**	**0.57**	**0.58**	**0.58**	**0.58**	IPOP-CMA-ES [22]
CMA+DE-MOS	23	23	21	**0.97**	**0.08**	**0.05**	**0.06**	**0.06**	**0.06**	**0.07**	CMA+DE-MOS [18]
NBC-CMA	8.2	8.0	7.3	91	*12e-1/1e4*	.	.	.	.	.	NBC-CMA [21]
POEMS	129	124	118	**2.4**	8.6	*30e-2/3e5*	.	.	.	.	POEMS [17]
PM-AdapSS-DE	51	51	46	*22e-1/1e5*	.	.	.	.	.	.	PM-AdapSS-DE [9, 10]
pPOEMS	128	128	134	**1.8**	*24e-2/3e5*	.	.	.	.	.	pPOEMS [17, 20]
Basic RCGA	10	10	10	*22e-1/5e4*	.	.	.	.	.	.	Basic RCGA [24]
SPSA	14	15	16	*22e-1/1e5*	.	.	.	.	.	.	SPSA [13]

Table 117: Running time excess ERT/$\text{ERT}_{\text{best 2009}}$ on f_{21} in **20-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

21 Gallagher 101 peaks

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
ERT_{best}/D	0.05	0.05	28	327	705	716	732	754	778	879	ERT_{best}/D
(1,2)-CMA-ES	**1**	**1**	13	8.3	10	10	11	11	10	9.1	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	**1**	**1**	5.9	**3.3**	3.6	3.5	3.4	3.4	3.3	**2.9**	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	**1**	**1**	7.2	4.9	4.0	4.0	3.9	3.8	3.7	3.3	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	**1**	**1**	6.8	9.3	9.1	9.0	8.9	8.6	8.4	7.4	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	**1**	**1**	**2.1**	3.6	4.7	4.6	4.5	4.4	4.3	3.8	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	**1**	**1**	3.9	4.7	4.8	4.7	4.7	4.5	4.4	3.9	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	**1**	**1**	**2.4**	**1.7**	**1.8**	**1.8**	**1.7**	**1.7**	**1.6**	**1.5**	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	**1**	**1**	3.8	**2.3**	**2.6**	**2.6**	**2.5**	**2.4**	**2.4**	**2.1**	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	**1**	**1**	3.5	5.5	5.4	5.3	5.2	5.1	4.9	4.4	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	**1**	**1**	3.3	4.6	3.9	3.8	3.8	3.7	3.6	3.2	(1+2ms)-CMA-ES [2]
Artif Bee Colony	**1**	**1**	5.0	22	25	26	27	30	35	85	Artif Bee Colony [8]
avg NEWUOA	**1**	**1**	3.2	5.7	**3.5**	**3.5**	**3.4**	**3.3**	**3.3**	**2.9**	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	**2.7**	106	**1.9**	211	217	214	210	204	197	175	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	**1**	**1**	12	613	568	560	547	531	515	456	Adap DE (F-AUC) [10]
DE (Uniform)	**1**	**1**	21	461	568	560	548	532	516	457	DE (Uniform) [9]
IPOP-aCMA-ES	**1**	**1**	**1.9**	81	66	65	64	62	60	54	IPOP-aCMA-ES [16]
IPOP-CMA-ES	**1**	**1**	3.7	139	110	108	106	103	100	88	IPOP-CMA-ES [22]
CMA+DE-MOS	**1**	**1**	11	262	285	281	275	268	260	231	CMA+DE-MOS [18]
NBC-CMA	**1**	**1**	84	69	59	58	56	55	53	47	NBC-CMA [21]
POEMS	**1**	**1**	11053	5970	*47e-1/3e5*	.	.	.	.	.	POEMS [17]
PM-AdapSS-DE	**1**	**1**	12	351	568	560	547	531	515	456	PM-AdapSS-DE [9, 10]
pPOEMS	**1**	**1**	137	1172	956	1186	1160	1127	1093	974	pPOEMS [17, 20]
Basic RCGA	**1**	**1**	119	103	85	85	86	97	96	87	Basic RCGA [24]
SPSA	3.5	251	597	1240	*18e-1/1e5*	.	.	.	.	.	SPSA [13]

Table 118: Running time excess ERT/ERT$_{\text{best 2009}}$ on f_{22} in **20-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

22 Gallagher 21 peaks

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
ERT$_{\text{best}}$/D	0.05	0.05	23	279	1175	1208	1247	1307	1342	6740	ERT$_{\text{best}}$/D
(1,2)-CMA-ES	**1**	**1**	10	27	124	120	116	111	108	22	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	**1**	**1**	8.8	13	21	20	20	19	18	3.7	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	**1**	**1**	8.2	13	17	16	16	15	15	**3.0**	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	**1**	**1**	35	22	37	36	35	34	33	6.6	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	**1**	**1**	18	6.6	**11**	**11**	**11**	**10**	**10**	**2.0**	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	**1**	**1**	**5.6**	7.7	16	16	15	15	14	**2.9**	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	**1**	**1**	9.0	**5.0**	28	27	26	25	24	4.9	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	**1**	**1**	**4.7**	13	27	26	25	24	24	4.7	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	**1**	**1**	17	9.4	15	14	14	13	13	**2.6**	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	**1**	**1**	10	**4.4**	**10**	**10**	**9.2**	**8.8**	**8.6**	**1.7**	(1+2ms)-CMA-ES [2]
Artif Bee Colony	**1**	**1**	10	47	77	578	*44e-3/1e5*	.	.	.	Artif Bee Colony [8]
avg NEWUOA	**1**	**1**	**2.0**	**5.6**	**14**	**13**	**13**	**12**	**12**	**2.4**	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	**1.9**	104	676	546	*20e-1/1e5*	.	.	.	.	.	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	**1**	**1**	675	1436	*26e-1/1e5*	.	.	.	.	.	Adap DE (F-AUC) [10]
DE (Uniform)	**1**	**1**	1580	989	*20e-1/1e5*	.	.	.	.	.	DE (Uniform) [9]
IPOP-aCMA-ES	**1**	**1**	462	264	*20e-1/6e4*	.	.	.	.	.	IPOP-aCMA-ES [16]
IPOP-CMA-ES	**1**	**1**	445	287	*20e-1/6e4*	.	.	.	.	.	IPOP-CMA-ES [22]
CMA+DE-MOS	**1**	**1**	536	797	677	659	638	610	594	118	CMA+DE-MOS [18]
NBC-CMA	**1**	**1**	323	350	*73e-1/1e4*	.	.	.	.	.	NBC-CMA [21]
POEMS	**1**	**1**	6453	6994	*73e-1/3e5*	.	.	.	.	.	POEMS [17]
PM-AdapSS-DE	**1**	**1**	1572	2332	*51e-1/1e5*	.	.	.	.	.	PM-AdapSS-DE [9, 10]
pPOEMS	**1**	**1**	2022	1439	1680	1634	1584	1513	1474	294	pPOEMS [17, 20]
Basic RCGA	**1**	**1**	1186	1200	*73e-1/5e4*	.	.	.	.	.	Basic RCGA [24]
SPSA	7.6	240	1073	1439	*26e-1/1e5*	.	.	.	.	.	SPSA [13]

Table 119: Running time excess $\mathrm{ERT}/\mathrm{ERT}_{\text{best 2009}}$ on f_{23} in **20-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

23 Katsuuras

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
$\mathrm{ERT}_{\text{best}}/D$	0.05	0.05	0.16	81	3373	18276	24442	25501	40551	41895	$\mathrm{ERT}_{\text{best}}/D$
(1,2)-CMA-ES	**1**	**1**	341	1833	*27e-1/1e4*	.	.	.	.	.	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	**1**	**1**	32	138	*97e-2/1e4*	.	.	.	.	.	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	**1**	**1**	50	387	*14e-1/1e4*	.	.	.	.	.	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	**1**	**1**	192	*34e-1/1e4*	.	.	.	.	.	.	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	**1**	**1**	45	107	*86e-2/1e4*	.	.	.	.	.	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	**1**	**1**	19	45	*38e-2/1e4*	.	.	.	.	.	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	**1**	**1**	17	122	*66e-2/1e4*	.	.	.	.	.	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	**1**	**1**	22	138	*81e-2/1e4*	.	.	.	.	.	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	**1**	**1**	18	**8.1**	*40e-2/1e4*	.	.	.	.	.	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	**1**	**1**	7.9	**6.0**	*38e-2/1e4*	.	.	.	.	.	(1+2ms)-CMA-ES [2]
Artif Bee Colony	**1**	**1**	**1.1**	78	*64e-2/1e5*	.	.	.	.	.	Artif Bee Colony [8]
avg NEWUOA	**1**	**1**	15	**4.7**	*20e-2/2e4*	.	.	.	.	.	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	**1.4**	66	55	*15e-1/1e5*	.	.	.	.	.	.	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	**1**	**1**	**1.5**	2385	440	*11e-1/1e5*	.	.	.	.	Adap DE (F-AUC) [10]
DE (Uniform)	**1**	**1**	3.0	6010	*13e-1/1e5*	.	.	.	.	.	DE (Uniform) [9]
IPOP-aCMA-ES	**1**	**1**	4.1	22809	*15e-1/1e5*	.	.	.	.	.	IPOP-aCMA-ES [16]
IPOP-CMA-ES	**1**	**1**	4.3	23082	*14e-1/1e5*	.	.	.	.	.	IPOP-CMA-ES [22]
CMA+DE-MOS	**1**	**1**	**2.1**	56	**8.9**	**14**	*29e-3/1e5*	.	.	.	CMA+DE-MOS [18]
NBC-CMA	**1**	**1**	**1.9**	*18e-1/1e4*	.	.	.	.	.	.	NBC-CMA [21]
POEMS	**1**	**1**	29	48	**47**	*90e-3/3e5*	.	.	.	.	POEMS [17]
PM-AdapSS-DE	**1**	**1**	**1.5**	8493	*13e-1/1e5*	.	.	.	.	.	PM-AdapSS-DE [9, 10]
pPOEMS	**1**	**1**	4.9	320	**36**	*60e-3/3e5*	.	.	.	.	pPOEMS [17, 20]
Basic RCGA	**1**	**1**	**2.7**	572	106	*26e-2/5e4*	.	.	.	.	Basic RCGA [24]
SPSA	4.7	868	2320	*16e-1/1e5*	.	.	.	.	.	.	SPSA [13]

Table 120: Running time excess ERT/ERT$_{\text{best 2009}}$ on f_{24} in **20-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

24 Lunacek bi-Rastrigin

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
ERT$_{\text{best}}$/D	0.05	331	66859	3.74e5	2.60e6	2.60e6	2.60e6	2.60e6	2.60e6	2.60e6	ERT$_{\text{best}}$/D
(1,2)-CMA-ES	**1**	*19e+1/1e4*	.	.	.	.	.	.	.	.	(1,2)-CMA-ES [5, 3]
(1,2m)-CMA-ES	**1**	11	*77e+0/1e4*	.	.	.	.	.	.	.	(1,2m)-CMA-ES [5]
(1,2ms)-CMA-ES	**1**	17	*90e+0/1e4*	.	.	.	.	.	.	.	(1,2ms)-CMA-ES [5]
(1,2s)-CMA-ES	**1**	450	*19e+1/1e4*	.	.	.	.	.	.	.	(1,2s)-CMA-ES [3]
(1,4)-CMA-ES	**1**	14	*85e+0/1e4*	.	.	.	.	.	.	.	(1,4)-CMA-ES [6, 4]
(1,4m)-CMA-ES	**1**	**2.1**	*62e+0/1e4*	.	.	.	.	.	.	.	(1,4m)-CMA-ES [6]
(1,4ms)-CMA-ES	**1**	**2.8**	*60e+0/1e4*	.	.	.	.	.	.	.	(1,4ms)-CMA-ES [1, 6]
(1,4s)-CMA-ES	**1**	14	*81e+0/1e4*	.	.	.	.	.	.	.	(1,4s)-CMA-ES [4]
(1+1)-CMA-ES	**1**	37	*97e+0/1e4*	.	.	.	.	.	.	.	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	**1**	15	*83e+0/1e4*	.	.	.	.	.	.	.	(1+2ms)-CMA-ES [2]
Artif Bee Colony	**1.1**	2078	*12e+1/1e5*	.	.	.	.	.	.	.	Artif Bee Colony [8]
avg NEWUOA	14	3.3	*74e+0/1e4*	.	.	.	.	.	.	.	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	184	7.3	**4.3**	*25e+0/1e5*	.	.	.	.	.	.	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	**1**	52	*83e+0/1e5*	.	.	.	.	.	.	.	Adap DE (F-AUC) [10]
DE (Uniform)	**1.2**	73	*81e+0/1e5*	.	.	.	.	.	.	.	DE (Uniform) [9]
IPOP-aCMA-ES	**1**	6.1	25	**4.5**	*20e+0/3e5*	.	.	.	.	.	IPOP-aCMA-ES [16]
IPOP-CMA-ES	**1**	5.5	*20e+0/3e5*	.	.	.	.	.	.	.	IPOP-CMA-ES [22]
CMA+DE-MOS	**1.1**	**1.9**	**1.7**	*89e-1/1e5*	.	.	.	.	.	.	CMA+DE-MOS [18]
NBC-CMA	**1.1**	*12e+1/1e4*	.	.	.	.	.	.	.	.	NBC-CMA [21]
POEMS	39	10	*42e+0/3e5*	.	.	.	.	.	.	.	POEMS [17]
PM-AdapSS-DE	**1**	21	*70e+0/1e5*	.	.	.	.	.	.	.	PM-AdapSS-DE [9, 10]
pPOEMS	**1.3**	55	64	*17e+0/3e5*	.	.	.	.	.	.	pPOEMS [17, 20]
Basic RCGA	**1**	47	**1.7**	*25e+0/5e4*	.	.	.	.	.	.	Basic RCGA [24]
SPSA	2.52e5	*86e+1/1e5*	.	.	.	.	.	.	.	.	SPSA [13]

Table 121: Running time excess $\mathrm{ERT}/\mathrm{ERT}_{\text{best 2009}}$ on f_1 in **40-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

1 Sphere

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
$\mathrm{ERT}_{\text{best}}/\mathrm{D}$	0.03	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	$\mathrm{ERT}_{\text{best}}/\mathrm{D}$
(1+1)-CMA-ES	**1**	**3.2**	**7.1**	**11**	**15**	**19**	**23**	**27**	**31**	**39**	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	**1**	**2.7**	**6.1**	**10**	**13**	**17**	**20**	**24**	**27**	**35**	(1+2ms)-CMA-ES [2]
avg NEWUOA	**1**	**3.2**	**3.2**	**3.2**	**3.2**	**3.2**	**3.2**	**3.2**	**3.2**	**3.2**	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	139	7.7	15	22	30	37	44	52	59	74	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	**1**	65	205	383	594	823	1086	1353	1573	2016	Adap DE (F-AUC) [10]
DE (Uniform)	**1**	113	376	642	898	1164	1442	1709	1982	2502	DE (Uniform) [9]
IPOP-aCMA-ES	**1**	3.3	10	16	21	28	34	40	46	58	IPOP-aCMA-ES [16]
IPOP-CMA-ES	**1**	3.3	9.4	16	21	27	33	39	45	57	IPOP-CMA-ES [22]
CMA+DE-MOS	**1**	18	50	58	65	76	106	126	134	162	CMA+DE-MOS [18]
NBC-CMA	**1**	4.7	12	19	26	32	38	45	52	66	NBC-CMA [21]
PM-AdapSS-DE	**1**	75	212	364	524	694	871	1063	1252	1643	PM-AdapSS-DE [9, 10]
Basic RCGA	**1**	12	72	1089	4155	5781	7051	8001	8768	9840	Basic RCGA [24]
SPSA	478	11	15	20	24	29	33	37	41	50	SPSA [13]

Table 122: Running time excess $\mathrm{ERT}/\mathrm{ERT}_{\mathrm{best\ 2009}}$ on f_2 in **40-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

2 Ellipsoid separable

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
$\mathrm{ERT}_{\mathrm{best}}$/D	20	20	20	20	20	20	20	20	20	20	$\mathrm{ERT}_{\mathrm{best}}$/D
(1+1)-CMA-ES	24	45	59	70	**76**	**80**	**82**	**84**	**85**	**86**	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	**19**	**34**	**45**	**55**	**61**	**64**	**68**	**69**	**70**	**71**	(1+2ms)-CMA-ES [2]
avg NEWUOA	**7.5**	**23**	**36**	**62**	79	99	117	135	145	179	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	80	104	118	129	135	140	144	145	146	148	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	48	77	115	149	176	201	230	257	284	335	Adap DE (F-AUC) [10]
DE (Uniform)	87	119	152	180	209	237	265	293	321	376	DE (Uniform) [9]
IPOP-aCMA-ES	**19**	**29**	**37**	**43**	**48**	**51**	**54**	**55**	**57**	**58**	IPOP-aCMA-ES [16]
IPOP-CMA-ES	29	46	61	70	77	82	85	87	88	90	IPOP-CMA-ES [22]
CMA+DE-MOS	42	72	95	110	120	130	138	142	147	155	CMA+DE-MOS [18]
NBC-CMA	42	83	121	146	165	182	194	202	213	226	NBC-CMA [21]
PM-AdapSS-DE	52	78	111	155	185	216	246	271	294	339	PM-AdapSS-DE [9, 10]
Basic RCGA	467	2454	*67e+0/5e4*	.	.	.	.	.	.	.	Basic RCGA [24]
SPSA	75834	*26e+2/1e5*	.	.	.	.	.	.	.	.	SPSA [13]

Table 123: Running time excess $\mathrm{ERT}/\mathrm{ERT}_{\mathrm{best\ 2009}}$ on f_3 in **40-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

3 Rastrigin separable

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
$\mathrm{ERT}_{\mathrm{best}}$/D	5.6	18	388	390	390	391	391	391	391	391	$\mathrm{ERT}_{\mathrm{best}}$/D
(1+1)-CMA-ES	**1.4**	*32e+1/1e4*	.	.	.	.	.	.	.	.	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	3.9	*31e+1/1e4*	.	.	.	.	.	.	.	.	(1+2ms)-CMA-ES [2]
avg NEWUOA	21	*38e+1/1e4*	.	.	.	.	.	.	.	.	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	3.1	725	*56e+0/1e5*	.	.	.	.	.	.	.	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	18	*22e+1/1e5*	.	.	.	.	.	.	.	.	Adap DE (F-AUC) [10]
DE (Uniform)	30	*23e+1/1e5*	.	.	.	.	.	.	.	.	DE (Uniform) [9]
IPOP-aCMA-ES	**1.1**	**9.1**	*15e+0/2e5*	.	.	.	.	.	.	.	IPOP-aCMA-ES [16]
IPOP-CMA-ES	**0.99**	**5.2**	*13e+0/2e5*	.	.	.	.	.	.	.	IPOP-CMA-ES [22]
CMA+DE-MOS	4.8	**27**	**46**	**54**	**56**	**58**	**59**	**61**	**63**	**66**	CMA+DE-MOS [18]
NBC-CMA	**1.5**	58	*72e+0/8e3*	.	.	.	.	.	.	.	NBC-CMA [21]
PM-AdapSS-DE	22	*20e+1/1e5*	.	.	.	.	.	.	.	.	PM-AdapSS-DE [9, 10]
Basic RCGA	**2.5**	618	*14e+0/5e4*	.	.	.	.	.	.	.	Basic RCGA [24]
SPSA	72023	*10e+3/1e5*	.	.	.	.	.	.	.	.	SPSA [13]

Table 124: Running time excess ERT/$\text{ERT}_{\text{best 2009}}$ on f_4 in **40-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

4 Skew Rastrigin-Bueche separ

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
ERT_{best}/D	11	134	388	390	391	392	393	393	393	7060	ERT_{best}/D
(1+1)-CMA-ES	24	*49e+1/1e4*	.	.	.	.	.	.	.	.	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	10	*51e+1/1e4*	.	.	.	.	.	.	.	.	(1+2ms)-CMA-ES [2]
avg NEWUOA	7.5	*36e+1/3e4*	.	.	.	.	.	.	.	.	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	**2.4**	405	*75e+0/1e5*	.	.	.	.	.	.	.	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	20	*23e+1/1e5*	.	.	.	.	.	.	.	.	Adap DE (F-AUC) [10]
DE (Uniform)	39	*22e+1/1e5*	.	.	.	.	.	.	.	.	DE (Uniform) [9]
IPOP-aCMA-ES	**0.98**	**3.1**	*30e+0/2e5*	.	.	.	.	.	.	.	IPOP-aCMA-ES [16]
IPOP-CMA-ES	**1.2**	**3.5**	*30e+0/2e5*	.	.	.	.	.	.	.	IPOP-CMA-ES [22]
CMA+DE-MOS	3.7	**5.6**	**116**	**118**	**152**	**154**	**155**	**156**	**157**	**8.9**	CMA+DE-MOS [18]
NBC-CMA	**1.3**	40	*90e+0/7e3*	.	.	.	.	.	.	.	NBC-CMA [21]
PM-AdapSS-DE	22	243	*60e+0/1e5*	.	.	.	.	.	.	.	PM-AdapSS-DE [9, 10]
Basic RCGA	**2.3**	78	*50e+0/5e4*	.	.	.	.	.	.	.	Basic RCGA [24]
SPSA	1411	*74e+1/1e5*	.	.	.	.	.	.	.	.	SPSA [13]

Table 125: Running time excess ERT/ERT$_{\text{best 2009}}$ on f_5 in **40-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

5 Linear slope

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
ERT$_{\text{best}}$/D	0.03	2.1	2.5	2.9	3.0	3.0	3.0	3.0	3.0	3.0	ERT$_{\text{best}}$/D
(1+1)-CMA-ES	**1**	**1.7**	**2.7**	**2.7**	**2.7**	**2.7**	**2.7**	**2.7**	**2.7**	**2.7**	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	**1**	**1.6**	**2.8**	**2.6**	**2.6**	**2.6**	**2.6**	**2.6**	**2.6**	**2.6**	(1+2ms)-CMA-ES [2]
avg NEWUOA	**1**	3.1	**3.1**	**3.2**	**3.4**	**3.4**	**3.4**	**3.4**	**3.4**	**3.4**	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	15	3.3	4.4	4.1	4.1	4.1	4.1	4.1	4.1	4.1	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	**1**	44	72	71	71	70	70	70	70	70	Adap DE (F-AUC) [10]
DE (Uniform)	**1**	69	96	89	86	86	86	86	86	86	DE (Uniform) [9]
IPOP-aCMA-ES	**1**	3.2	4.8	4.6	4.5	4.5	4.5	4.5	4.5	4.5	IPOP-aCMA-ES [16]
IPOP-CMA-ES	**1**	3.2	4.9	4.7	4.7	4.6	4.6	4.7	4.7	4.7	IPOP-CMA-ES [22]
CMA+DE-MOS	**1.1**	29	41	36	35	35	35	35	35	35	CMA+DE-MOS [18]
NBC-CMA	**1**	*14e+1/8e3*	.	.	.	.	.	.	.	.	NBC-CMA [21]
PM-AdapSS-DE	**1**	91	135	123	119	119	119	119	119	119	PM-AdapSS-DE [9, 10]
Basic RCGA	**1.1**	265	3925	5230	6166	6845	7299	7583	32644	*11e-6/5e4*	Basic RCGA [24]
SPSA	25	**2.7**	5.2	5.1	5.0	5.0	5.0	5.0	5.0	5.0	SPSA [13]

Table 126: Running time excess ERT/$\mathrm{ERT}_{\mathrm{best\ 2009}}$ on f_6 in **40-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

6 Attractive sector

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
$\mathrm{ERT}_{\mathrm{best}}$/D	4.9	46	88	138	179	237	288	332	375	481	$\mathrm{ERT}_{\mathrm{best}}$/D
(1+1)-CMA-ES	**3.6**	10	298	*17e+0/1e4*	.	.	.	.	.	.	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	**2.7**	5.6	1605	*13e+0/1e4*	.	.	.	.	.	.	(1+2ms)-CMA-ES [2]
avg NEWUOA	**4.7**	**1.5**	**1.3**	**1.3**	**1.2**	**1.2**	**1.1**	**1.2**	**1.1**	**1.1**	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	20	4.5	4.0	3.7	3.8	3.7	4.0	4.4	5.1	12	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	82	33	32	30	32	30	30	30	30	30	Adap DE (F-AUC) [10]
DE (Uniform)	245	70	58	51	50	46	44	45	45	43	DE (Uniform) [9]
IPOP-aCMA-ES	5.2	**1.7**	**1.5**	**1.4**	**1.4**	**1.3**	**1.3**	**1.3**	**1.3**	**1.3**	IPOP-aCMA-ES [16]
IPOP-CMA-ES	6.3	**1.8**	**1.7**	**1.5**	**1.5**	**1.4**	**1.4**	**1.4**	**1.4**	**1.4**	IPOP-CMA-ES [22]
CMA+DE-MOS	21	5.3	4.4	3.7	3.4	3.1	**3.0**	**2.9**	**2.8**	**2.7**	CMA+DE-MOS [18]
NBC-CMA	63	59	32	21	16	13	11	9.4	8.8	7.5	NBC-CMA [21]
PM-AdapSS-DE	120	41	38	35	35	34	35	36	38	39	PM-AdapSS-DE [9, 10]
Basic RCGA	35	107	128	107	105	88	79	73	147	1505	Basic RCGA [24]
SPSA	9975	*42e+1/1e5*	.	.	.	.	.	.	.	.	SPSA [13]

Table 127: Running time excess ERT/$\text{ERT}_{\text{best 2009}}$ on f_7 in **40-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

7 Step-ellipsoid

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
ERT_{best}/D	2.6	31	267	446	1026	1657	1657	1657	1657	1704	ERT_{best}/D
(1+1)-CMA-ES	**2.0**	99	48	*85e-1/1e4*	.	.	.	.	.	.	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	**1.5**	53	35	*84e-1/1e4*	.	.	.	.	.	.	(1+2ms)-CMA-ES [2]
avg NEWUOA	**2.6**	5.4	*24e+0/4e4*	.	.	.	.	.	.	.	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	6.7	**1.7**	308	*97e-1/1e5*	.	.	.	.	.	.	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	25	11	3.3	279	636	406	406	406	406	395	Adap DE (F-AUC) [10]
DE (Uniform)	37	20	5.2	**5.5**	**3.3**	**2.8**	**2.8**	**2.8**	**2.8**	**2.9**	DE (Uniform) [9]
IPOP-aCMA-ES	**1.6**	**1.00**	**1.2**	**2.5**	**1.5**	**0.99**	**0.99**	**0.99**	**0.99**	**0.97**	IPOP-aCMA-ES [16]
IPOP-CMA-ES	**1.6**	**1.1**	**1.6**	**5.5**	**2.6**	**1.7**	**1.7**	**1.7**	**1.7**	**1.7**	IPOP-CMA-ES [22]
CMA+DE-MOS	8.2	3.5	**1.9**	8.2	4.1	**2.7**	**2.7**	**2.7**	**2.7**	**2.6**	CMA+DE-MOS [18]
NBC-CMA	**2.4**	**1.2**	**1.6**	*49e-1/8e3*	.	.	.	.	.	.	NBC-CMA [21]
PM-AdapSS-DE	32	12	3.0	20	67	57	57	57	57	55	PM-AdapSS-DE [9, 10]
Basic RCGA	5.1	6.2	29	*43e-1/5e4*	.	.	.	.	.	.	Basic RCGA [24]
SPSA	18	1650	*94e+0/1e5*	.	.	.	.	.	.	.	SPSA [13]

Table 128: Running time excess ERT/$\text{ERT}_{\text{best 2009}}$ on f_8 in **40-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

8 Rosenbrock original

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
ERT_{best}/D	13	40	177	266	275	282	286	289	293	299	ERT_{best}/D
(1+1)-CMA-ES	**1.5**	**1.9**	8.4	11	11	11	11	11	11	11	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	**1.2**	**1.0**	**6.9**	8.1	8.4	8.4	8.4	8.5	8.5	8.5	(1+2ms)-CMA-ES [2]
avg NEWUOA	**1.9**	**1.7**	**1.2**	**1.6**	**1.6**	**1.6**	**1.6**	**1.6**	**1.6**	**1.6**	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	3.1	**2.8**	8.4	10	11	11	11	11	11	11	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	38	25	78	128	129	129	130	130	130	130	Adap DE (F-AUC) [10]
DE (Uniform)	75	43	107	119	122	122	123	123	124	125	DE (Uniform) [9]
IPOP-aCMA-ES	**1.9**	**1.3**	**5.2**	**4.5**	**4.6**	**4.7**	**4.7**	**4.7**	**4.7**	**4.7**	IPOP-aCMA-ES [16]
IPOP-CMA-ES	**2.0**	**1.8**	6.9	**6.3**	**6.5**	**6.5**	**6.5**	**6.6**	**6.6**	**6.5**	IPOP-CMA-ES [22]
CMA+DE-MOS	8.2	3.2	18	17	17	17	17	17	17	17	CMA+DE-MOS [18]
NBC-CMA	**2.3**	**1.6**	13	14	15	16	16	16	16	16	NBC-CMA [21]
PM-AdapSS-DE	39	24	156	139	144	146	148	149	150	150	PM-AdapSS-DE [9, 10]
Basic RCGA	14	133	*36e+0/5e4*	.	.	.	.	.	.	.	Basic RCGA [24]
SPSA	99	1950	*39e+0/1e5*	.	.	.	.	.	.	.	SPSA [13]

Table 129: Running time excess ERT/ERT$_{\text{best 2009}}$ on f_9 in **40-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

9 Rosenbrock rotated

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
ERT$_{\text{best}}$/D	0.03	35	153	325	333	337	341	345	348	354	ERT$_{\text{best}}$/D
(1+1)-CMA-ES	**662**	**1.3**	9.3	6.8	7.1	7.2	7.2	7.3	7.3	7.4	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	**588**	**1.1**	**7.4**	6.0	6.2	6.3	6.3	6.4	6.4	6.5	(1+2ms)-CMA-ES [2]
avg NEWUOA	**851**	**1.3**	**1.4**	**1.1**	**1.1**	**1.2**	**1.2**	**1.2**	**1.2**	**1.2**	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	1663	3.3	11	9.1	9.4	9.4	9.5	9.5	10	10	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	14031	19	97	61	64	66	67	68	69	70	Adap DE (F-AUC) [10]
DE (Uniform)	34294	46	121	75	78	80	81	82	83	85	DE (Uniform) [9]
IPOP-aCMA-ES	921	**1.4**	**6.3**	**5.8**	**5.9**	**6.0**	**6.0**	**6.0**	**6.0**	**6.0**	IPOP-aCMA-ES [16]
IPOP-CMA-ES	878	**1.4**	8.1	**5.7**	**5.9**	**5.9**	**6.0**	**6.0**	**6.0**	**6.0**	IPOP-CMA-ES [22]
CMA+DE-MOS	3026	**2.9**	20	14	14	14	14	14	14	14	CMA+DE-MOS [18]
NBC-CMA	1082	**1.9**	15	14	19	19	19	19	20	19	NBC-CMA [21]
PM-AdapSS-DE	15292	22	192	142	146	149	150	151	151	152	PM-AdapSS-DE [9, 10]
Basic RCGA	2065	202	*36e+0/5e4*	.	.	.	.	.	.	.	Basic RCGA [24]
SPSA	4.48e5	11672	*23e+1/1e5*	.	.	.	.	.	.	.	SPSA [13]

Table 130: Running time excess ERT/$\text{ERT}_{\text{best 2009}}$ on f_{10} in **40-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

10 Ellipsoid

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
ERT_{best}/D	165	402	647	759	920	1289	1400	1516	1628	1771	ERT_{best}/D
(1+1)-CMA-ES	**2.8**	**2.0**	**1.7**	**1.7**	**1.6**	**1.2**	**1.2**	**1.1**	**1.0**	**0.98**	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	**2.1**	**1.6**	**1.4**	**1.4**	**1.3**	**0.98**	**0.95**	**0.90**	**0.85**	**0.79**	(1+2ms)-CMA-ES [2]
avg NEWUOA	**1.3**	**1.6**	**1.4**	**1.9**	**1.8**	**1.7**	**1.8**	**1.9**	**1.9**	**2.1**	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	8.2	4.7	3.5	3.3	**2.9**	**2.1**	**2.0**	**1.9**	**1.8**	**1.7**	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	5.8	3.9	3.6	4.0	4.0	3.3	3.4	3.4	3.5	3.8	Adap DE (F-AUC) [10]
DE (Uniform)	10	5.7	4.5	4.5	4.4	3.5	3.7	3.7	3.8	4.2	DE (Uniform) [9]
IPOP-aCMA-ES	**2.2**	**1.4**	**1.1**	**1.1**	**1.0**	**0.80**	**0.77**	**0.74**	**0.70**	**0.67**	IPOP-aCMA-ES [16]
IPOP-CMA-ES	3.2	**2.3**	**1.9**	**1.9**	**1.7**	**1.3**	**1.2**	**1.2**	**1.1**	**1.0**	IPOP-CMA-ES [22]
CMA+DE-MOS	6.2	4.7	4.0	4.0	3.6	**2.7**	**2.6**	**2.4**	**2.3**	**2.2**	CMA+DE-MOS [18]
NBC-CMA	5.7	4.3	3.7	4.0	3.7	**2.9**	**2.8**	**2.7**	**2.6**	**2.6**	NBC-CMA [21]
PM-AdapSS-DE	6.3	3.7	3.2	3.5	3.6	3.0	3.2	3.4	3.5	3.7	PM-AdapSS-DE [9, 10]
Basic RCGA	*99e+2/5e4*	.	.	.	.	.	.	.	.	.	Basic RCGA [24]
SPSA	*77e+2/1e5*	.	.	.	.	.	.	.	.	.	SPSA [13]

Table 131: Running time excess ERT/$\mathrm{ERT}_{\mathrm{best\ 2009}}$ on f_{11} in **40-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

11 Discus

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
$\mathrm{ERT}_{\mathrm{best}}$/D	1.8	23	59	121	292	633	744	858	974	1205	$\mathrm{ERT}_{\mathrm{best}}$/D
(1+1)-CMA-ES	16	**9.5**	7.8	5.9	3.3	**2.0**	**2.1**	**2.2**	**2.3**	**2.4**	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	20	**7.6**	**6.0**	**4.6**	**2.7**	**1.6**	**1.7**	**1.8**	**1.8**	**1.9**	(1+2ms)-CMA-ES [2]
avg NEWUOA	3.4	**5.5**	**3.9**	**2.8**	**1.5**	**0.89**	**0.91**	**0.90**	**0.91**	**0.90**	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	11999	1197	557	361	181	235	922	1658	1464	1184	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	**3.1**	14	11	9.2	5.5	3.3	3.5	3.6	3.8	3.9	Adap DE (F-AUC) [10]
DE (Uniform)	3.6	26	19	14	7.6	4.4	4.5	4.5	4.6	4.6	DE (Uniform) [9]
IPOP-aCMA-ES	43	12	**5.0**	**2.7**	**1.2**	**0.58**	**0.51**	**0.46**	**0.43**	**0.37**	IPOP-aCMA-ES [16]
IPOP-CMA-ES	71	34	15	7.7	3.4	**1.6**	**1.4**	**1.3**	**1.2**	**0.98**	IPOP-CMA-ES [22]
CMA+DE-MOS	**1.7**	60	29	16	7.2	3.5	3.1	**2.8**	**2.6**	**2.2**	CMA+DE-MOS [18]
NBC-CMA	**2.3**	*25e+1/8e3*	.	.	.	.	.	.	.	.	NBC-CMA [21]
PM-AdapSS-DE	10	18	12	8.6	4.8	**2.9**	**3.0**	3.1	3.2	3.3	PM-AdapSS-DE [9, 10]
Basic RCGA	3.5	9247	12154	*14e+1/5e4*	.	.	.	.	.	.	Basic RCGA [24]
SPSA	*25e+2/1e5*	.	.	.	.	.	.	.	.	.	SPSA [13]

Table 132: Running time excess $\mathrm{ERT}/\mathrm{ERT}_{\mathrm{best\ 2009}}$ on f_{12} in **40-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

12 Bent cigar

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
$\mathrm{ERT}_{\mathrm{best}}$/D	27	31	104	186	229	269	329	526	569	630	$\mathrm{ERT}_{\mathrm{best}}$/D
(1+1)-CMA-ES	**1.8**	**1.9**	**1.9**	3.2	4.4	4.8	4.9	3.6	4.1	4.4	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	**1.6**	**2.1**	**1.7**	**2.5**	**3.6**	**4.0**	**4.2**	**3.2**	**3.5**	**4.1**	(1+2ms)-CMA-ES [2]
avg NEWUOA	**2.1**	8.4	21	24	31	38	42	32	39	86	avg NEWUOA [23]
CMA-EGS (IPOP,r1)	3.8	5.9	5.8	7.4	9.3	10	9.4	7.0	7.9	9.3	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	83	87	41	36	40	40	39	28	30	31	Adap DE (F-AUC) [10]
DE (Uniform)	119	122	41	29	35	38	39	30	32	34	DE (Uniform) [9]
IPOP-aCMA-ES	**2.8**	**2.9**	**1.1**	**1.3**	**1.7**	**1.9**	**1.8**	**1.3**	**1.3**	**1.3**	IPOP-aCMA-ES [16]
IPOP-CMA-ES	**2.7**	**2.8**	**2.3**	**2.5**	**2.8**	**2.9**	**2.8**	**2.0**	**2.1**	**2.2**	IPOP-CMA-ES [22]
CMA+DE-MOS	9.0	8.5	4.3	6.6	7.0	7.5	6.8	4.7	4.9	5.0	CMA+DE-MOS [18]
NBC-CMA	3.1	3.2	4.2	5.9	7.0	8.8	9.1	6.5	6.6	6.7	NBC-CMA [21]
PM-AdapSS-DE	73	75	26	30	37	43	48	40	45	51	PM-AdapSS-DE [9, 10]
Basic RCGA	555	543	194	172	328	2683	*78e-3/5e4*	.	.	.	Basic RCGA [24]
SPSA	53521	*20e+6/1e5*	.	.	.	.	.	.	.	.	SPSA [13]

Table 133: Running time excess ERT/$\text{ERT}_{\text{best 2009}}$ on f_{13} in **40-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

13 Sharp ridge

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
ERT_{best}/D	3.7	10	51	173	218	297	1798	2098	2462	2985	ERT_{best}/D
(1+1)-CMA-ES	**3.2**	**3.4**	3.1	5.4	10	25	10	8.6	14	23	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	**2.9**	**2.9**	**2.8**	**3.2**	**7.2**	**14**	7.0	16	29	*82e-5/1e4*	(1+2ms)-CMA-ES [2]
CMA-EGS (IPOP,r1)	7.6	6.4	**2.7**	4.2	37	215	780	669	570	*67e-4/1e5*	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	78	105	37	17	18	17	3.3	3.3	3.2	3.3	Adap DE (F-AUC) [10]
DE (Uniform)	145	168	54	22	23	20	4.0	3.9	3.8	3.9	DE (Uniform) [9]
IPOP-aCMA-ES	**4.4**	**4.7**	**1.6**	**2.1**	**4.7**	**5.9**	**1.3**	**1.4**	**1.6**	**1.9**	IPOP-aCMA-ES [16]
IPOP-CMA-ES	4.8	5.1	**2.8**	**3.5**	**6.6**	**10**	**2.3**	**2.9**	**2.7**	**2.9**	IPOP-CMA-ES [22]
CMA+DE-MOS	26	14	6.4	7.0	11	15	**3.1**	3.4	**3.2**	3.6	CMA+DE-MOS [18]
NBC-CMA	5.6	5.7	**2.5**	5.0	16	26	10	25	*63e-4/7e3*	.	NBC-CMA [21]
PM-AdapSS-DE	85	102	34	15	16	15	3.1	**3.2**	3.2	**3.3**	PM-AdapSS-DE [9, 10]
Basic RCGA	29	733	319	177	724	1169	402	*20e-2/5e4*	.	.	Basic RCGA [24]
SPSA	75	4772	14665	8631	6843	*52e+0/1e5*	.	.	.	.	SPSA [13]

Table 134: Running time excess ERT/$\text{ERT}_{\text{best 2009}}$ on f_{14} in **40-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

14 Sum of different powers

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
ERT_{best}/D	0.03	0.04	7.6	15	19	28	55	91	121	1443	ERT_{best}/D
(1+1)-CMA-ES	**1**	**36**	**1.7**	**1.6**	**1.8**	**2.1**	**2.0**	**3.0**	**5.1**	**1.0**	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	**1**	57	**1.7**	**1.5**	**1.7**	**1.9**	**1.9**	**2.7**	**4.2**	**0.85**	(1+2ms)-CMA-ES [2]
CMA-EGS (IPOP,r1)	85	316	5.4	3.8	4.3	5.1	6.3	10	19	4.3	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	**1**	128	38	46	63	68	47	37	34	4.0	Adap DE (F-AUC) [10]
DE (Uniform)	**1**	74	72	80	99	95	61	45	40	4.5	DE (Uniform) [9]
IPOP-aCMA-ES	**1**	**31**	**2.5**	**2.4**	**3.0**	**3.7**	**3.4**	**3.5**	**3.9**	**0.57**	IPOP-aCMA-ES [16]
IPOP-CMA-ES	**1**	**32**	**2.7**	**2.5**	3.0	3.9	4.3	5.2	6.7	**1.1**	IPOP-CMA-ES [22]
CMA+DE-MOS	**1.1**	118	12	7.8	7.7	10	12	16	19	**2.7**	CMA+DE-MOS [18]
NBC-CMA	**1.1**	44	**2.9**	**2.6**	3.2	4.4	5.3	8.1	11	**1.8**	NBC-CMA [21]
PM-AdapSS-DE	**1.1**	90	44	47	59	60	41	32	30	3.7	PM-AdapSS-DE [9, 10]
Basic RCGA	**1**	51	12	28	366	484	1403	*10e-4/5e4*	.	.	Basic RCGA [24]
SPSA	195	1670	58	41	36	33	41	130	6065	*22e-6/1e5*	SPSA [13]

Table 135: Running time excess ERT/$\mathrm{ERT}_{\mathrm{best\ 2009}}$ on f_{15} in **40-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

15 Rastrigin

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
$\mathrm{ERT}_{\mathrm{best}}$/D	4.8	190	4699	19671	26216	26587	26959	27330	27694	28439	$\mathrm{ERT}_{\mathrm{best}}$/D
(1+1)-CMA-ES	**1.8**	*35e+1/1e4*	.	.	.	.	.	.	.	.	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	4.8	*32e+1/1e4*	.	.	.	.	.	.	.	.	(1+2ms)-CMA-ES [2]
CMA-EGS (IPOP,r1)	3.4	46	*48e+0/1e5*	.	.	.	.	.	.	.	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	22	*23e+1/1e5*	.	.	.	.	.	.	.	.	Adap DE (F-AUC) [10]
DE (Uniform)	39	*23e+1/1e5*	.	.	.	.	.	.	.	.	DE (Uniform) [9]
IPOP-aCMA-ES	**1.3**	**1.1**	**0.76**	**0.55**	**0.64**	**0.64**	**0.65**	**0.65**	**0.66**	**0.67**	IPOP-aCMA-ES [16]
IPOP-CMA-ES	**1.3**	**1.2**	**0.80**	**0.60**	**0.70**	**0.70**	**0.71**	**0.71**	**0.72**	**0.73**	IPOP-CMA-ES [22]
CMA+DE-MOS	7.5	**1.8**	**1.9**	**1.1**	**1.3**	**1.3**	**1.3**	**1.3**	**1.3**	**1.3**	CMA+DE-MOS [18]
NBC-CMA	**1.8**	57	*12e+1/8e3*	.	.	.	.	.	.	.	NBC-CMA [21]
PM-AdapSS-DE	28	*20e+1/1e5*	.	.	.	.	.	.	.	.	PM-AdapSS-DE [9, 10]
Basic RCGA	4.0	156	76	*13e+0/5e4*	.	.	.	.	.	.	Basic RCGA [24]
SPSA	14116	*52e+1/1e5*	.	.	.	.	.	.	.	.	SPSA [13]

Table 136: Running time excess ERT/$\text{ERT}_{\text{best 2009}}$ on f_{16} in **40-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

16 Weierstrass

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
ERT_{best}/D	0.03	0.03	131	1803	8037	17771	35172	49254	49707	50540	ERT_{best}/D
(1+1)-CMA-ES	**1**	**1.1**	346	*11e+0/1e4*	.	.	.	.	.	.	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	**1**	**1**	146	*10e+0/1e4*	.	.	.	.	.	.	(1+2ms)-CMA-ES [2]
CMA-EGS (IPOP,r1)	**1**	202	5.9	48	*82e-2/1e5*	.	.	.	.	.	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	**1**	**1**	*27e+0/1e5*	.	.	.	.	.	.	.	Adap DE (F-AUC) [10]
DE (Uniform)	**1**	**1**	*27e+0/1e5*	.	.	.	.	.	.	.	DE (Uniform) [9]
IPOP-aCMA-ES	**1**	**1.1**	**0.89**	**0.91**	**0.91**	**0.74**	**0.46**	**0.78**	**0.96**	**1.0**	IPOP-aCMA-ES [16]
IPOP-CMA-ES	**1**	**1.2**	**0.94**	**1.2**	**1.0**	**0.71**	**0.46**	**0.38**	**0.38**	**0.39**	IPOP-CMA-ES [22]
CMA+DE-MOS	**1**	**1.2**	**0.88**	**0.17**	**0.97**	**2.0**	**5.7**	**5.5**	**5.5**	**5.4**	CMA+DE-MOS [18]
NBC-CMA	**1**	**1.1**	413	30	*27e+0/7e3*	.	.	.	.	.	NBC-CMA [21]
PM-AdapSS-DE	**1**	**1.1**	*24e+0/1e5*	.	.	.	.	.	.	.	PM-AdapSS-DE [9, 10]
Basic RCGA	**1**	**1.2**	19	5.7	4.2	8.8	*37e-3/5e4*	.	.	.	Basic RCGA [24]
SPSA	**1**	24706	1031	*12e+0/1e5*	.	.	.	.	.	.	SPSA [13]

Table 137: Running time excess ERT/$\text{ERT}_{\text{best 2009}}$ on f_{17} in **40-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

17 Schaffer F7, condition 10

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
ERT_{best}/D	0.03	0.03	10	106	354	874	1299	2216	3331	6637	ERT_{best}/D
(1+1)-CMA-ES	**1**	**1**	58	*68e-1/1e4*	.	.	.	.	.	.	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	**1**	5.3	234	*68e-1/1e4*	.	.	.	.	.	.	(1+2ms)-CMA-ES [2]
CMA-EGS (IPOP,r1)	168	304	**2.8**	**0.68**	**1.2**	**1.5**	**2.0**	**2.1**	3.7	7.0	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	**1**	**1.2**	18	12	13	322	*15e-3/1e5*	.	.	.	Adap DE (F-AUC) [10]
DE (Uniform)	**1**	**1.4**	41	20	13	8.3	8.0	17	17	34	DE (Uniform) [9]
IPOP-aCMA-ES	**1**	**2.8**	**1.0**	**0.51**	**1.1**	**1.1**	**1.2**	**1.0**	**1.00**	**0.79**	IPOP-aCMA-ES [16]
IPOP-CMA-ES	**1**	**1.7**	**1.0**	**0.50**	**1.0**	**1.1**	**1.1**	**0.99**	**0.99**	**0.84**	IPOP-CMA-ES [22]
CMA+DE-MOS	**1**	**1.3**	8.0	**1.4**	**1.0**	**0.87**	**1.2**	**1.3**	**1.2**	**1.1**	CMA+DE-MOS [18]
NBC-CMA	**1**	**1.2**	**1.0**	**0.77**	**1.1**	60	*24e-3/8e3*	.	.	.	NBC-CMA [21]
PM-AdapSS-DE	**1**	**1.4**	21	13	30	82	505	*74e-4/1e5*	.	.	PM-AdapSS-DE [9, 10]
Basic RCGA	**1**	**1.2**	**2.0**	7.0	32	18	15	18	104	*40e-6/5e4*	Basic RCGA [24]
SPSA	1.60e7	1.60e7	*10e+3/1e5*	.	.	.	.	.	.	.	SPSA [13]

Table 138: Running time excess ERT/$\text{ERT}_{\text{best 2009}}$ on f_{18} in **40-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

18 Schaffer F7, condition 1000

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
ERT_{best}/D	0.03	0.05	36	425	1177	3179	4685	6422	16776	23736	ERT_{best}/D
(1+1)-CMA-ES	**1**	38	*26e+0/1e4*	.	.	.	.	.	.	.	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	**1**	60	*25e+0/1e4*	.	.	.	.	.	.	.	(1+2ms)-CMA-ES [2]
CMA-EGS (IPOP,r1)	177	217	**1.4**	**0.49**	**1.4**	**1.1**	**1.3**	**3.0**	3.1	6.8	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	**1**	25	19	5.2	18	442	*48e-3/1e5*	.	.	.	Adap DE (F-AUC) [10]
DE (Uniform)	**1.1**	22	35	7.5	4.8	**2.7**	**2.5**	6.5	13	28	DE (Uniform) [9]
IPOP-aCMA-ES	**1**	25	**1.0**	**0.62**	**0.98**	**0.69**	**0.70**	**0.88**	**0.49**	**0.51**	IPOP-aCMA-ES [16]
IPOP-CMA-ES	**1**	29	**0.97**	**0.66**	**1.1**	**0.85**	**0.86**	**1.0**	**0.74**	**1.4**	IPOP-CMA-ES [22]
CMA+DE-MOS	**1.1**	17	3.5	**0.84**	**1.1**	**0.95**	**1.1**	**1.4**	**1.0**	**1.1**	CMA+DE-MOS [18]
NBC-CMA	**1**	**15**	**1.3**	**0.58**	*18e-2/7e3*	.	.	.	.	.	NBC-CMA [21]
PM-AdapSS-DE	**1**	**8.0**	20	4.5	3.4	29	*90e-4/1e5*	.	.	.	PM-AdapSS-DE [9, 10]
Basic RCGA	**1**	**10**	6.6	19	12	5.8	14	*95e-5/5e4*	.	.	Basic RCGA [24]
SPSA	5.60e7	2.80e7	*12e+3/1e5*	.	.	.	.	.	.	.	SPSA [13]

Table 139: Running time excess ERT/$\text{ERT}_{\text{best 2009}}$ on f_{19} in **40-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

19 Griewank-Rosenbrock F8F2

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
ERT_{best}/D	0.03	0.03	0.03	0.03	34806	4.21e5	6.38e5	1.13e6	1.13e6	1.14e6	ERT_{best}/D
(1+1)-CMA-ES	**1**	**1**	5510	*41e-1/1e4*	.	.	.	.	.	.	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	**1**	**1**	7249	*38e-1/1e4*	.	.	.	.	.	.	(1+2ms)-CMA-ES [2]
CMA-EGS (IPOP,r1)	64	204	934	1.22e5	*45e-2/1e5*	.	.	.	.	.	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	**1**	**1**	5034	*50e-1/1e5*	.	.	.	.	.	.	Adap DE (F-AUC) [10]
DE (Uniform)	**1**	**1**	13186	*51e-1/1e5*	.	.	.	.	.	.	DE (Uniform) [9]
IPOP-aCMA-ES	**1**	**1**	**458**	**49920**	**0.57**	**0.38**	**0.33**	**0.20**	**0.20**	**0.21**	IPOP-aCMA-ES [16]
IPOP-CMA-ES	**1**	**1**	**442**	**67521**	**0.64**	**0.38**	**0.31**	**0.21**	**0.21**	**0.22**	IPOP-CMA-ES [22]
CMA+DE-MOS	**1**	**1.1**	3026	**64253**	**2.6**	*66e-3/1e5*	.	.	.	.	CMA+DE-MOS [18]
NBC-CMA	**1**	**1**	624	*65e-1/8e3*	.	.	.	.	.	.	NBC-CMA [21]
PM-AdapSS-DE	**1**	**1.1**	6161	*47e-1/1e5*	.	.	.	.	.	.	PM-AdapSS-DE [9, 10]
Basic RCGA	**1**	**1.1**	**416**	1.87e6	*44e-2/5e4*	.	.	.	.	.	Basic RCGA [24]
SPSA	185	581	14521	*55e-1/1e5*	.	.	.	.	.	.	SPSA [13]

Table 140: Running time excess ERT/ERT$_{\text{best 2009}}$ on f_{20} in **40-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

20 Schwefel x*sin(x)

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
ERT$_{\text{best}}$/D	3.1	4.3	5.5	3284	4.03e6	∞	∞	∞	∞	∞	ERT$_{\text{best}}$/D
(1+1)-CMA-ES	**3.5**	**3.0**	**2.6**	*13e-1/1e4*	.	.	.	.	.	.	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	**3.4**	**2.9**	**2.5**	*14e-1/1e4*	.	.	.	.	.	.	(1+2ms)-CMA-ES [2]
CMA-EGS (IPOP,r1)	10	8.3	7.0	*19e-1/1e5*	.	.	.	.	.	.	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	70	59	52	*30e-1/1e5*	.	.	.	.	.	.	Adap DE (F-AUC) [10]
DE (Uniform)	154	134	116	*29e-1/1e5*	.	.	.	.	.	.	DE (Uniform) [9]
IPOP-aCMA-ES	**5.1**	**4.3**	**3.7**	**8.4**	**0.19**	*12e-2/3e5*	.	.	.	.	IPOP-aCMA-ES [16]
IPOP-CMA-ES	5.5	4.9	4.1	**15**	**0.33**	*14e-2/3e5*	.	.	.	.	IPOP-CMA-ES [22]
CMA+DE-MOS	25	20	16	**3.8**	**0.01**	**1.84e6**	**1.95e6**	**2.04e6**	**2.26e6**	**2.50e6**	CMA+DE-MOS [18]
NBC-CMA	6.6	6.0	5.1	*14e-1/7e3*	.	.	.	.	.	.	NBC-CMA [21]
PM-AdapSS-DE	79	69	58	*30e-1/1e5*	.	.	.	.	.	.	PM-AdapSS-DE [9, 10]
Basic RCGA	8.2	8.9	8.5	*23e-1/5e4*	.	.	.	.	.	.	Basic RCGA [24]
SPSA	11	10	10	*22e-1/1e5*	.	.	.	.	.	.	SPSA [13]

Table 141: Running time excess ERT/ERT$_{\text{best 2009}}$ on f_{21} in **40-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

21 Gallagher 101 peaks

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
ERT$_{\text{best}}$/D	0.03	0.03	26	529	2518	2525	2533	2542	2548	2560	ERT$_{\text{best}}$/D
(1+1)-CMA-ES	**1**	**1**	**5.0**	**1.9**	**0.97**	**0.97**	**0.97**	**0.97**	**0.97**	**0.97**	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	**1**	**1**	**2.4**	**2.3**	**1.1**	**1.1**	**1.1**	**1.1**	**1.1**	**1.1**	(1+2ms)-CMA-ES [2]
CMA-EGS (IPOP,r1)	20	224	14	107	62	62	62	62	62	62	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	**1**	**1**	293	758	258	258	257	256	256	255	Adap DE (F-AUC) [10]
DE (Uniform)	**1**	**1**	36	287	557	555	553	552	550	548	DE (Uniform) [9]
IPOP-aCMA-ES	**1**	**1**	9.2	161	118	118	118	117	117	116	IPOP-aCMA-ES [16]
IPOP-CMA-ES	**1**	**1**	10	166	83	83	83	83	82	82	IPOP-CMA-ES [22]
CMA+DE-MOS	**1**	**1**	15	224	101	101	101	100	100	100	CMA+DE-MOS [18]
NBC-CMA	**1**	**1**	73	199	42	42	41	41	41	41	NBC-CMA [21]
PM-AdapSS-DE	**1**	**1**	295	1231	*21e-1/1e5*	.	.	.	.	.	PM-AdapSS-DE [9, 10]
Basic RCGA	**1**	**1**	**7.7**	**89**	**31**	**33**	**33**	**34**	**34**	**35**	Basic RCGA [24]
SPSA	188	541	880	2650	*25e-1/1e5*	.	.	.	.	.	SPSA [13]

Table 142: Running time excess ERT/$\text{ERT}_{\text{best 2009}}$ on f_{22} in **40-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

22 Gallagher 21 peaks

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
ERT_{best}/D	0.03	0.03	77	886	16210	16230	16250	16273	16297	16351	ERT_{best}/D
(1+1)-CMA-ES	**1**	**1**	**9.1**	**6.2**	**2.0**	**2.0**	**2.0**	**2.0**	**2.0**	**2.0**	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	**1**	**1**	**1.9**	**4.9**	**9.0**	**8.9**	**8.9**	**8.9**	**8.9**	**8.9**	(1+2ms)-CMA-ES [2]
CMA-EGS (IPOP,r1)	21	205	326	226	*20e-1/1e5*	.	.	.	.	.	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	**1**	**1**	478	312	*26e-1/1e5*	.	.	.	.	.	Adap DE (F-AUC) [10]
DE (Uniform)	**1**	**1**	661	453	*73e-1/1e5*	.	.	.	.	.	DE (Uniform) [9]
IPOP-aCMA-ES	**1**	**1**	295	174	*20e-1/7e4*	.	.	.	.	.	IPOP-aCMA-ES [16]
IPOP-CMA-ES	**1**	**1**	367	133	*20e-1/8e4*	.	.	.	.	.	IPOP-CMA-ES [22]
CMA+DE-MOS	**1**	**1**	490	205	*20e-1/1e5*	.	.	.	.	.	CMA+DE-MOS [18]
NBC-CMA	**1**	**1**	**49**	**23**	*51e-1/7e3*	.	.	.	.	.	NBC-CMA [21]
PM-AdapSS-DE	**1**	**1**	654	1581	*56e-1/1e5*	.	.	.	.	.	PM-AdapSS-DE [9, 10]
Basic RCGA	**1**	**1**	335	101	*20e-1/5e4*	.	.	.	.	.	Basic RCGA [24]
SPSA	183	630	769	737	*51e-1/1e5*	.	.	.	.	.	SPSA [13]

Table 143: Running time excess ERT/$\text{ERT}_{\text{best 2009}}$ on f_{23} in **40-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

23 Katsuuras

Δftarget	1e+03	1e+02	1e+01	1e+00	1e-01	1e-02	1e-03	1e-04	1e-05	1e-07	Δftarget
ERT_{best}/D	0.03	0.03	0.18	298	1886	16522	31967	78995	81054	84011	ERT_{best}/D
(1+1)-CMA-ES	**1**	**1**	9.0	**10**	*65e-2/1e4*	.	.	.	.	.	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	**1**	**1**	9.0	**12**	*69e-2/1e4*	.	.	.	.	.	(1+2ms)-CMA-ES [2]
CMA-EGS (IPOP,r1)	21	156	61	*26e-1/1e5*	.	.	.	.	.	.	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	**1**	**1**	**1.7**	*26e-1/1e5*	.	.	.	.	.	.	Adap DE (F-AUC) [10]
DE (Uniform)	**1**	**1**	**0.75**	*28e-1/1e5*	.	.	.	.	.	.	DE (Uniform) [9]
IPOP-aCMA-ES	**1**	**1**	8.3	*25e-1/1e5*	.	.	.	.	.	.	IPOP-aCMA-ES [16]
IPOP-CMA-ES	**1**	**1**	7.9	*26e-1/1e5*	.	.	.	.	.	.	IPOP-CMA-ES [22]
CMA+DE-MOS	**1**	**1**	**1.1**	**41**	**18**	**19**	**46**	*19e-3/1e5*	.	.	CMA+DE-MOS [18]
NBC-CMA	**1**	**1**	**1.8**	*30e-1/7e3*	.	.	.	.	.	.	NBC-CMA [21]
PM-AdapSS-DE	**1**	**1**	**1.9**	*26e-1/1e5*	.	.	.	.	.	.	PM-AdapSS-DE [9, 10]
Basic RCGA	**1**	**1**	**1.2**	149	**40**	**44**	*77e-3/5e4*	.	.	.	Basic RCGA [24]
SPSA	235	1095	2014	*26e-1/1e5*	.	.	.	.	.	.	SPSA [13]

Table 144: Running time excess ERT/$\text{ERT}_{\text{best 2009}}$ on f_{24} in **40-D**, in italics is given the median final function value and the median number of function evaluations to reach this value divided by dimension

24 Lunacek bi-Rastrigin

Δftarget ERT_{best}/D	1e+03 0.03	1e+02 967	1e+01 1.46e5	1e+00 2.45e6	1e-01 7.50e6	1e-02 7.51e6	1e-03 7.51e6	1e-04 7.51e6	1e-05 7.51e6	1e-07 7.51e6	Δftarget ERT_{best}/D
(1+1)-CMA-ES	230	*33e+1/1e4*	.	.	.	.	.	.	.	.	(1+1)-CMA-ES [7]
(1+2ms)-CMA-ES	**193**	*35e+1/1e4*	.	.	.	.	.	.	.	.	(1+2ms)-CMA-ES [2]
CMA-EGS (IPOP,r1)	1051	**13**	**4.6**	*51e+0/1e5*	.	.	.	.	.	.	CMA-EGS (IPOP,r1) [12]
Adap DE (F-AUC)	3020	*24e+1/1e5*	.	.	.	.	.	.	.	.	Adap DE (F-AUC) [10]
DE (Uniform)	5239	*26e+1/1e5*	.	.	.	.	.	.	.	.	DE (Uniform) [9]
IPOP-aCMA-ES	209	**13**	*41e+0/2e5*	.	.	.	.	.	.	.	IPOP-aCMA-ES [16]
IPOP-CMA-ES	221	26	*41e+0/2e5*	.	.	.	.	.	.	.	IPOP-CMA-ES [22]
CMA+DE-MOS	1061	**2.5**	**2.4**	*28e+0/1e5*	.	.	.	.	.	.	CMA+DE-MOS [18]
NBC-CMA	**102**	*35e+1/7e3*	.	.	.	.	.	.	.	.	NBC-CMA [21]
PM-AdapSS-DE	2988	*20e+1/1e5*	.	.	.	.	.	.	.	.	PM-AdapSS-DE [9, 10]
Basic RCGA	**167**	48	*59e+0/5e4*	.	.	.	.	.	.	.	Basic RCGA [24]
SPSA	*22e+2/1e5*	.	.	.	.	.	.	.	.	.	SPSA [13]

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